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A REVIEW

OF

The Doctrine

OF A

VITAL PRINCIPLE,

AS MAINTAINED BY

SOME WRITERS ON PHYSIOLOGY.

WITH

Observations

ON THE

CAUSES OF PHYSICAL & ANIMAL LIFE.

BY J. C. PRICHARD, M.D. F.R.S. &c.

> “ Experiar mihi quæ comperta videntur,
> Sintne satis perspecta et certis cognita signis;
> An vanæ tantum species, et amabilis error
> Me noscendi avidum falsâ sub imagine ludat.”
>
> *Mus. Angl.* 2. 133.

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TO THE

FOUNDERS AND PATRONS

OF THE

Bristol Philosophical Institution,

ESPECIALLY TO

RICHARD BRIGHT, Esq. F.G.S. &c.

AND TO

JOHN SCANDRETT HARFORD, Esq. D.C.L. F.R.S.

WHO HAVE BEEN FROM THE COMMENCEMENT

AMONG THE VICE-PRESIDENTS AND MOST MUNIFICENT

SUPPORTERS OF THE INSTITUTION,

THIS WORK IS DEDICATED,

BY THE AUTHOR.

PREFACE.

THE following pages contain the substance of a Paper, which was read at one of the Meetings of the Literary and Philosophical Society annexed to the Bristol Institution. By several persons who were present on that occasion, a desire was expressed that the Paper might be printed, and with that suggestion I determined to comply, after making some alterations and additions which appeared to be requisite. I am aware that the Work will still bear traces of the purpose for which it was originally destined, but this could not easily be avoided, and it is a circumstance of little importance.

In laying this treatise before the public, I make no claim of bringing forward a discovery of new facts in physiology. Yet I am induced to hope that, such as it is, the Work may not be altogether without its use. The subject is one in relation to which vague and, as I believe, erroneous opinions have prevailed to a considerable extent. A careful and dispassionate examination of various questions connected with it, appears to be on many accounts requisite, especially for the advantage of students of a particular class, who, owing to a variety of circumstances, are in a peculiar manner liable to imbibe prejudices, the result of partial views and inadequate information. Even in a more general point of view, it seems to be desirable that some distinctions should be recognized, which, to the best of my ability, I have endeavoured, in the following pages, to draw. I observe that a late writer of great celebrity has thought it incumbent upon him to ward off the charge of materialism, when entering on an inquiry as to the immediate agencies concerned in the phenomena of merely physical or organic life,* and it is no uncommon thing to hear the metaphysical doctrine of the existence of a Soul, confounded with the physiological theory of a Vital Principle.

If, in prosecuting the inquiry pointed out by the title of this Essay, I may appear to have treated with little deference the opinions of some writers, who have merited a distinguished place in the public regard, I hope that I shall not on that account be thought failing in the respect which is personally due to them, and which nobody is more willing than myself to testify. In relation to matters of philosophical discussion, the free examination of opinions must be conceded to all, without reference to the individuals who respectively may have maintained them.

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* See the advertisement of M. Dutrochet's Work, entitled "L'agent immédiat du mouvement vital dévoilé dans sa nature et dans sa mode d'action, chez les végétaux et chez les animaux."

The views which I have taken of some leading facts in the animal economy, are different from those which, for many years, have been most popular in this country, but they nearly coincide with the opinions of some distinguished writers both in England and on the Continent.* To several of these I am under obligations, but to none of them so extensively as to an excellent teacher of physiology, whose lectures, delivered many years ago at Edinburgh, contributed there to introduce more correct principles of reasoning on subjects connected with the animal economy, than those which have been followed in some other medical schools.†

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* See Note 4.

† Mr. Allen, formerly Lecturer on Physiology at Edinburgh.

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A REVIEW OF THE DOCTRINE

OF

A VITAL PRINCIPLE,

&c. &c.

SECTION I.

INTRODUCTORY REMARKS—ORIGIN OF THE THEORY OF A VITAL PRINCIPLE, OR ANIMA.

IT has been a favourite attempt of modern writers on natural history, to trace a gradation or scale of being through the whole extent of the material creation; in the animal kingdom, through all its tribes and orders; and among the several families of plants, down to the inorganic bodies, which belong to the mineral world. There is, however, a wide chasm in this pretended series, which no intermediate link can ever be found to fill up. Animals and plants are connected together by a great number of striking analogies, but there the relation ends; and between organized creatures and the products of crystallization, or any other mode of attraction or aggregation, by which unorganized matter is held together, in masses great or small, there is a total want of resemblance. In this instance no analogy can be traced, except what is vague and chimerical. It is so much the more interesting to observe the points of agreement, the general characters of affinity, which are discoverable between the various classes of organized beings. In the more remarkable laws of their existence, a common nature may be said to unite beings of the highest rank in the animated world, with the lichens and the mushrooms, which constitute the lowest, or the simplest orders in vegetation. To exist in successive generations, which, one after another, rise, flourish, and decay; to begin from ova or seeds; to grow to a definite extent by means of the accretion of particles from the surrounding elements, imbibed by peculiar organs; to assume a particular form; to subsist in perfection for a definite space of time; and then, after giving origin to new germs or rudiments, destined, according to certain laws, to secure the preservation of each tribe, to fall at length a prey to the dissolving powers of the external elements, are properties common to all organized beings; common alike to the lords of the creation, and to the pot-herbs and legumes which contribute to their daily food. But beyond the limits of the animal and vegetable kingdoms, none of these phenomena can be discovered. Simplicity of structure, preservation of the same form and dimension, perpetuity of existence, so far as our ideas and knowledge of time extend, belong alike to the smallest molecules in the unorganized creation, and to those great masses, which, revolving in the heavens, age after age, have offered themselves to the view of countless generations. In almost every particular that can be predicated of either, organic beings differ from, and present a contrast to the unorganized.

The efficient cause of organization, the influence which holds together bodies composed of common elements, in so many peculiar yet various forms, and, in the manner above alluded to, perpetuates their succession, has been a theme of curious inquiry among philosophers in every age.

We cannot imagine any method of investigation more likely to throw light upon this mysterious subject, than that of observing the phenomena displayed at the extinction of life in an organized being, and comparing its state at this period, with the condition of its parts and entire substance while still possessed of vitality.

While life continues in an animal or a plant, it subsists entire in its substance, undissolved, and, in a great measure, unaffected by the surrounding elements; defended either by some peculiar principle, or by some circumstances in its state or condition, from the chemical agencies of the external bodies, whether solid, fluid, or aëriform, which come into contact with it. But no sooner has life abandoned it, than all these agents are found to be capable of exerting upon it their proper influences. Heat and moisture give rise to fermentation in its substance; the atmosphere acts upon it from without; dissolution of its structure follows, and the particles of which it is composed are, sooner or later, dissipated.

To those who contemplated these phenomena with the desire of accounting for them, it was an obvious and a natural conjecture, that an unknown something has abandoned the body at the hour of death, which, during the living state, had preserved its integrity; and that it is owing to the loss of this preserving principle, that the dissolution of the fabric has ensued. This notion seems to have occurred to men in various countries and at very early periods, for the expressions to which it has given rise, are to be traced in many ancient languages. The terms by which the soul is distinguished were evidently derived, in these languages, from some of the most remarkable operations or properties of corporeal life. The words πνεῦμα, ψυχὴ, *anima*, *spiritus*, *the breath of life*, were originally allusive to the essential functions of the living body, and were intended to designate the hidden cause, the principle of physical existence on which they were supposed to depend.*

---

* Thus in Hebrew the two words which correspond with *soul* and *spirit*, נֶפֶשׁ *Nephesh*, and רוּחַ *Ruach*, are derived; the former from a root preserved in Arabic (نفس) signifying *spiravit*, *respiravit*, and the latter from רוּחַ *spirare*, or properly *odorem spirare*.

In Sanskrit, the word atmā (अत्मा) i. e. *spirit*, πνεῦμα, Such was the rude beginning of metaphysics; and it is probable that no further step was for a long while gained in the same path. The principle of animation, or that which maintains in activity the functions of the body, was looked upon as the centre also of feeling and of inward consciousness; for conscious feeling and the faculties of the mind appear to have their beginning, and cease to be displayed at the same periods with the ordinary phenomena of life. But after a time it was observed, that the properties of merely corporeal life pervade the lowest tribes of the animal kingdom, and are even common, under a certain modification, to plants; while those attributes of a higher order are far more limited in their distribution. Hence the existence of another and a distinct principle was at length inferred. This new principle or entity, which

signifies also *wind*, *air*, and prani (प्राणी) *a sentient being*, pranah, (प्राण:) life, vitality, soul, are derived from pra (प्र) *præ*, πρὸ, and (अन) the root of the verb ANYAMAI (अन्यमे) *respiro*, whence also the Latin *anima*, and Greek ἄνεμος.

In Greek, πνεῦμα and ψυχὴ, are well known to be connected with the same idea.

was looked upon as the centre, or the source of all endowments of a higher nature, was to be distinguished by a particular appellation, and we find that this purpose was attained in different ways. In some instances, the old expression for the principle of vitality was modified by a new ending: *anima*, which in the feminine gender had signified the cause of animation, the source of physical life, became, with a masculine termination, *animus*, the mind, or intellectual power.* But, in other instances, an entirely new term was invented, derived from the characteristic attributes of the thing to be described. The Latin word *mens,* and the English *mind,* signified, originally, that which knows or understands, and are derived from the root *mena,** to know, an etymon, which, though lost in the European languages, is preserved, like many of their common roots, in the Sanskrit; and the Greeks used the word νοῦς, from a verb of exactly the same meaning. Thus it appears that two distinct principles were recognized, though it must be allowed that the ancients were not very accurate in the distribution of properties between them, or in this respect unanimous either among themselves, or with the metaphysical writers of later times. Sensation, as well as the passions or affections, are considered by them as belonging to the ψυχὴ, or principle of life, rather than to the mind; and the terms which belong to either of these enti-

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* The respective meanings of *anima* and *animus* are clearly marked in a passage of Juvenal, which has frequently been cited.

—— Mundi
Principio indulsit communis conditor illis
Tantum animas, nobis animum quoque, mutuus ut nos
Adfectus petere auxilium et præstare juberet;
Dispersos trahere in populum; migrare vetusto
De nemore, et proavis habitatas linquere silvas;
Ædificare domos; Laribus conjungere nostris
Tectum aliud——

—— defendier îsdem
Turribus, atque una portarum clave teneri.

Ruperti's note on this passage contains exactly the meaning which I have expressed in the text. "*Anima*, Gr. ψυχὴ, est id quo vivunt, sentiunt, ac moventur et homines et cætera animantia, quæ inde nomen habent, vis vitalis, vegetabilis ac sensitiva, quæ plantis etiam et arboribus tribuitur:

---

animus, νοῦς et φρὴν, est mens, vel id quod in nobis cogitat, intelligit ac vult, et quo sapimus.

* From the root mĕnă (मन) come the verb (मनुते) menutai, intelligit, *mente* tenet, μηνύει, he *means*, and a great variety of European words alluding to the *mind*.

ties, are sometimes used with little discrimination.

A similar observation of phenomena, and a corresponding disposition to speculate concerning their causes, led many in later times, whose peculiar studies rendered them conversant with physiological subjects, to adopt notions not very different from those which may be traced among the ancients. But the theories framed by modern writers have had their origin under very different circumstances from those which preceded them. By the language and opinion prevalent in modern times, and founded on religion and philosophy, the mental faculties, the thinking power, the passions,—all that belongs to the intellectual and moral nature of man, has been included among the proper attributes of the soul, a principle entirely distinct from the body. The existence of this principle, its nature and modes of operation, have been looked upon as matters to be discussed by divines and philosophers, rather than by physiologists. The latter have accordingly turned their attention more particularly to the phenomena of physical or merely corporeal life, and they have there found ample room for speculation and conjecture. Physiological writers have not dwelt exclusively on the phenomena of growth and decay, of life and death; they have been forcibly struck, at different periods, by certain facts connected with the processes carried on in the body during health and disease, which indicate a tendency in the internal actions of the living machine to the preservation of its existence, and to the renewal of its organs and inward structure, when these have sustained partial injury. These tendencies have not been ascribed in general to mechanism, to the original organization of the self-moving and self-preserving machine. Physiologists have been disposed to look out rather for some mysterious agent, residing in the living body itself, to whose continued operation the phenomena observed might be referred. The phrases of many writers on this subject are vague and indefinite. The Φύσις of Hippocrates had scarcely assumed the character we have described; but in the works of authors modern in comparison of him, particularly in those of Paracelsus and Van Helmont, we find expressions no longer doubtful. Their *Archæus*, or presiding spirit, becomes a "deus è machinâ," a provisional agent, and almost an intelligent and reflective being.

In general, the theories of physiological writers respecting the principle of physical life, which they supposed to preside over the growth and developement of the body, have been fluctuating, and enounced in terms so obscure, that it is difficult to distinguish whether this principle was to be reckoned among merely physical and material agents, or among immaterial beings. It is only of late years, and particularly since the time of John Hunter, that these speculations have assumed anything like a definite character.

SECTION II.

VIEW OF THE THEORY AS MAINTAINED BY MODERN WRITERS, AND PRINCIPALLY BY MR. HUNTER AND HIS FOLLOWERS.

THE discovery of electricity formed an era in the history of natural philosophy. The existence of a subtile agent, possessed of some of the properties of matter, and apparently destitute of certain qualities which have been usually found in conjunction with them, intangible, invisible, and only known by its effects, was a new fact, and seemed to open a wide field for speculation. A new class of beings or entities was thus made known, which seemed to exist between the opposite confines of matter and spirit, and to partake in a degree of the nature of both. This discovery was laid hold of by physiologists. The vital principle was imagined to be a substance of a similar kind in many respects, if not to be absolutely identified with the electric fluid. As the electric fluid appears to be endowed with the property of modifying, under particular circumstances, the ordinary influence of chemical affinity, and of controlling in a certain degree the usual operation of its laws, so the vital principle, which was supposed to be diffused through the body in the living state, and to pervade every texture and every part, was imagined to protect the whole from the chemical agencies of the surrounding elements. When death takes place, it was supposed that this influence is withdrawn, and that the fabric of the body is thus left, as common matter, a prey to the common agencies of the atmosphere.

The same analogies were resorted to for an explanation of other leading phenomena of life. It had long been a difficult problem among physiologists, to explain the theory of secretion, or to account for the elaboration of all the various secreted fluids of the body, such as tears, milk, bile, from one homogeneous liquid, namely, the blood, which is known to be the common source and material of them all. The structure of the secreting glands, in which this conversion or separation takes place, and to which the blood is conveyed in the course of circulation, in order that it may undergo the changes destined to be there effected, had been partially explained by Malpighi, Ruysch, and some early anatomists; but the knowledge obtained of the texture and organization of these parts, though it displayed a curiously contrived mechanism in the vascular apparatus of the glands, was very insufficient to elucidate the phenomena of secretion. It was now conjectured that the vital principle contributes a certain aid, or assists the glandular structure in separating so many different substances from the blood, and this it was supposed to do by exerting, over the chemical affinities of the particles which enter into the composition of that fluid, a modifying influence, and disposing them to form new and peculiar combinations. In this instance an analogy was traced, or rather imagined, between the electric fluid and the vital principle, which was endowed with a power of controlling the ordinary affinities, or the elective attractions of particles, and was supposed thus to give origin to new combinations, different from those which, under ordinary circumstances, the same particles are prone to form.

The production of animal heat is another property of living bodies, which was in like manner attributed to the vital principle. Animals are known to maintain a temperature different from that of the media in which they live. Generally, the specific temperature of each tribe is above the degree of heat proper to the atmosphere or fluid in which it exists. Under other circumstances, the same bodies are colder than the surrounding media, as when human beings have lived for a space of time in air heated to the degree of 240, or even 260, without having the temperature of their bodies raised much above the usual standard. This property of maintaining an uniform temperature, this function, at one time frigorific, and at others calorific, according to the exigencies of the occasion, was thought to be another operation of the vital principle.

Digestion, or that process in the animal economy, by which nutritive particles are separated from the aliment and assimilated to the blood, so as constantly to supply its ordinary expenditure, is another function of the living body, which is but imperfectly explained by the knowledge hitherto acquired of the means provided by Nature for its accomplishment. Physiologists and medical theorists had long ago called in the aid of imaginary agents. The *Archæus*, or presiding spirit, which had its seat in the stomach, and watched over the separation of alimentary matter into two portions, one to be received and the other to be rejected, is a figment well known in the history of medicine. This long-ago exploded doctrine was revived in a new form by modern physiologists. The vital principle, though not professedly invested with the attribute of intelligence, was nevertheless thought to be capable of performing the office ascribed to the *spiritus archæus*. It was supposed to effect, or to assist in the preparation of chyme, to modify the affinities of its component particles, in such a manner as to prevent their running into fermentation, as the same materials are known to do, when exposed, out of the body, to similar circumstances of temperature and fluidity. From this controlling agency, chyme, and afterwards chyle, were supposed to be the result, instead of the common products of fermentation.

That there are certain tendencies, in the internal and imperceptible processes of the living body, of a salutary and preservative result, is a fact which has been known, with more or less of evidence, since the time of Hippocrates. In the works of physicians and anatomists, of different ages and of different schools, we find allusions to this observation. The 'healing power of Nature,' is an expression frequently used, and against which no exception can be taken, if it is applied with philosophical caution and precision, merely as a general term for certain facts observed in the animal economy. But many writers have fallen unawares into the habit of ascribing some further and more mysterious meaning to this expression, and have used it as if they meant to speak of a real entity, a sort of in-dwelling guardian of the body. This *vis medicatrix*, or *conservatrix*, is therefore one of the multiform appearances of the vital or plastic principle, which, according to those writers who maintained its existence, presides over the functions in the state of health; and when any accidental cause of disturbance has given rise to a temporary disorder in the system, exerts itself to the best of its ability, with a sort of instinctive effort, often well directed, though sometimes liable to mistake, to restore the healthful and regular condition.

To the operations of this plastic or formative principle, the beginnings of life have also been referred, the developement of organic structure from seeds and germs, and from the ova of animals.

It must be observed, that those physiologists who have most confidently asserted the existence of a vital principle, have never furnished a tangible and convincing proof, by any fact or decisive experiment, which might display immediate and unequivocal evidence of its operation or presence. For I think we are not obliged to except from this remark the phenomena on which the celebrated Mr. Hunter and his followers have laid so much stress, and on which they have founded so many fanciful inferences. I allude to the appearances exhibited by the blood, when drawn from the vessels, and in the process of coagulation. The view which the disciples of the Hunterian school take of these phenomena, is well known to all those who have directed their attention to physiological subjects. The vital principle, or the matter of life, according to Mr. Hunter, for it was regarded by him as a substance highly attenuated, is not only diffused through all the solid parts of the body, but also pervades the fluids, and none so remarkably as the blood. It is this principle that keeps the blood, when circulating, in a state of fluidity, preventing its coagulation, or the hardening of the mass of fibrin, which takes place when the blood is poured out of the vessels. Accordingly, when a quantity of blood flows into a basin, it is for a time, in the language of Mr. Hunter, truly alive. It soon dies, however, or is abandoned by the vital principle; and the last act of life is, like the convulsion which often takes place in the entire body at the moment of dissolution, a sort of stiffening and contraction, which produces the condensation of substance.

I have thus attempted to afford some general idea of the modern doctrine of a vital principle, chiefly as it has prevailed among the followers of Mr. Hunter, and, indeed, very generally among the physiologists of this and some other countries. I have endeavoured to avoid any misrepresentation of this hypothesis, by giving a more extravagant account of it, than the opinions of its advocates require. I shall now proceed to examine the pretensions which are brought in favour of this doctrine, by those who consider it to be entitled to the character of a philosophical theory.

SECTION III.

OF THE METHOD OF INVESTIGATION—APOLOGY FOR HYPOTHETICAL THEORIES.

It has been laid down by Sir Isaac Newton as the first rule of philosophizing, that "we are to admit no more causes of natural things, or of the phenomena of Nature, than such as are both true and sufficient to explain their appearances." "Causas rerum naturalium non plures admitti debere, quam quæ et veræ sint et earum phænomenis explicandis sufficiant." This has been received as one of the fundamental laws of reasoning by natural philosophers, and a deduction has been made from it, that whenever a philosophical theory is proposed, or an attempt made to account for particular phenomena, it is incumbent upon us, in the first place, to give some direct proof that the cause assigned is a thing which really exists, before we proceed to inquire whether it is sufficient to explain the appearances which are to be accounted for. On this ground, we are forbidden to infer the existence of any agent whatever, from the circumstance that it affords, when once supposed, an explanation of the phenomena ascribed to its agency. But though this construction has been put upon Newton's expressions, it was not the purpose which he had really in view, as any body may be convinced, by referring to the remarks which, in his Principia, follow the passage I have just cited.* It must, indeed, be allowed that there are many subjects on which we are strongly disposed to speculate, and with respect to which philosophers have generally adopted some theoretical opinion, although it is impossible to examine them with a strict adherence to those rules which logicians have endeavoured to establish on the authority of Newton.

Writers on logic and metaphysics, who have to do with abstractions, and with modes of their own creating, may lay down rules of philosophizing, as rigid as they please; but those who are occupied in pursuing physical inquiries, become aware that the narrow extent of their actual knowledge, and the limited opportunity of interrogating Nature by experiment, will sometimes put them under the necessity of transgressing such maxims; or, at least, of yielding to them an imperfect and partial obedience. It must be acknowledged by every body, that a theory which has in its favour both of the requisites above described, fully and completely, is entitled to the highest regard, and must be placed on a very different ground from that of a mere hypothesis, be it ever so probable. The theory of gravitation is, perhaps, the best example which the whole compass of natural philosophy affords of such a theory, complete in every respect, and strictly deserving the title of a philosophical doctrine. In that instance, the principle proposed for the explanation of phenomena is first ascertained beyond all doubt, as a matter of fact, and it is afterwards shown to be competent to the explanation of all the phenomena ascribed to it. But there are few examples of reasoning on the laws of Nature so successful, and we are often obliged to rest satisfied with theories which cannot lay claim to so high a title. We are, in many instances, accustomed to infer the reality of causes from their apparent effects, such effects constituting indeed the only evidence that we can obtain of the existence of many agents in Nature, whose power and operation are sufficiently manifest. There are circumstances and modifications under which this way of reasoning must be accounted legitimate, though it is no easy matter to lay down the precise rules on this subject.

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* Principia, lib. 3, initio.

In general, there are two things to be chiefly considered, in respect to any hypothesis proposed with a view of accounting for phenomena not hitherto explained; these are, first, the question how far the assigned cause affords a solution of the results which are ascribed to its operation; and, secondly, *what degree of evidence* can be discovered, independently of this consideration, for establishing the existence of the supposed agent, as a matter of fact or probability. This last inquiry ought, perhaps, to take the lead, or to occupy our minds in the first instance. If the assigned cause is a thing whose existence admits of no doubt, we have, in what relates to this branch of the argument, the greatest advantage that can be desired. Such is the case in the theory by which Newton explained the revolutions of the heavenly bodies on the principle of gravitation. But if such an assurance that we are proceeding on safe ground cannot be obtained, it only remains for us to look round in search of probabilities, or arguments derived from analogy. We have then to survey the subject in its general bearings, and to inquire what relation the causes assigned display, to other agents whose existence is well ascertained, or whether their operation is conformable to the general laws and analogies of Nature. In this manner we may estimate the probability of an hypothesis, examine circumspectly the ground on which it stands, and prepare ourselves for approaching it in a more exact scrutiny.

The consideration which remains, is at least of equal importance to the preceding step in the inquiry. It is now to be determined how far the assigned cause,—whether proved to exist with certainty or with high probability, or only suggested as a possible fact, which may be styled the lowest degree of previous evidence,—how far, being either proved or conceded, it will enable us to explain the phenomena.

Different opinions have been maintained by logicians, and writers on the inductive philosophy, as to the value of hypotheses, which have but a low degree of previous evidence. And yet I think it must be admitted, by all those who will candidly reflect upon the subject, that there may be cases to which a simple hypothesis shall obtain a high degree of assent. Such hypotheses, when successful, have been compared to a variety of analogous things; to the key that fits and opens a lock, to the clue or solution of an enigma, and to the key of a cypher. Now, in either of these cases,—if the lock has been very difficult to open, very complicated in its construction;—if the riddle was such as could be explained in no other way;—if the cypher could only be interpreted by a single key,—the discovery would carry with it such a degree of evidence as to require no additional aid. The last of these illustrations has been adopted by Dr. Hartley, and has been applied by him to his conjectural doctrine respecting the human mind. "Supposing," he says, "the existence of the *æther*," (the agent to his system,) "to be destitute of all direct evidence, still, if it serves to explain and account for a great variety of phenomena, it will, by this means, have an indirect argument in its favour. Thus, we admit the key of a cypher to be a true one, when it explains the cypher completely; and the decypherer judges himself to approach to the true key, in proportion as he advances in the explanation of the cypher; and this without any direct evidence at all." On another occasion, he observes that "Philosophy is the art of decyphering the mysteries of Nature; and that every theory which can explain all the phenomena, has the same evidence in its favour, that it is possible the key of a cypher can have, from its explaining that cypher." These observations of Hartley's have given rise to some controversy, and Dr. Reid, in his review of that author's theory, has urged, in objection to them, that "to find the key requires an understanding equal or superior to that which made the cypher." The last remark is unworthy of Dr. Reid. He has been much more successful in shewing that Dr. Hartley's theory is inadequate to explain the phenomena which it is meant to elucidate; and this is, indeed, the consideration which has led to its rejection by philosophers.

Of a very different kind is the objection made by the late Mr. Stewart to the argument above cited from Dr. Hartley, on the subject of hypothetical reasoning. He observes, "that there are few, if any, physical hypotheses, which afford the only way of explaining the phenomena to which they are applied; and, therefore, admitting them to be perfectly consistent with all the known facts, they leave us in the same state of uncertainty in which the decypherer would find himself, if he should discover a variety of keys to the same cypher." In support of this position, Mr. Stewart refers to the assertion of Descartes, that on the principles of his philosophy, the same effect might in many instances admit of manifold explanations, and that nothing puzzled him more than to know which he ought to adopt in preference of others. "The same remark," says Mr. Stewart, "may, with a very few exceptions, be extended to every hypothetical theory which is *unsupported by any collateral proba-*

bilities arising from experience or analogy; and it sufficiently shows how infinitely inferior such theories are, in point of evidence, to the conclusions obtained by the art of the decypherer."

These remarks are entitled to a respectful consideration, if it were only in regard to the quarter whence they proceed. It must be allowed that we ought to exercise caution in admitting any hypothetical theory, which is wholly unsupported by *collateral probability*, by *fact or analogy;* and that no physical hypothesis can claim the same *degree* of evidence in its favour as that which belongs to the discovery of a decypherer, unless it really does afford the only possible method of solving the phenomena which are to be explained. But, if I am not mistaken, there are many theories with which philosophers are in general well satisfied, and yet, perhaps, in favour of which no other *species* of evidence can be adduced, or reasonably expected. Mr. Stewart himself admits that the Copernican system was an hypothesis of this description. He says, "the only evidence which the author was able to offer in its favour, was the advantage which it possessed over every other hypothesis in explaining, with simplicity and beauty, all the phenomena of the heavens. In the mind of Copernicus, therefore, this system was nothing more than an hypothesis; but it was an hypothesis conformable to the universal analogy of Nature, always accomplishing her ends by the simplest means." "C'est pour la simplicité," says Bailly, "que Copernic replaça le soleil au centre du monde; c'est pour elle que Kepler va détruire tous les epicycles que Copernic avoit laissé subsister."

No observations of mine can place in a stronger point of view, than does this example, the value which really belongs to a physical hypothesis, when it furnishes a sufficient clue to all the phenomena which are to be explained, and when it is perceived to afford the only solution that the case admits. At the same time, though we may hold in some degree of estimation a successful hypothesis, merely on the ground above stated, we must bear in mind the expediency of securing for it additional evidence, by showing that it proceeds on principles which are conformable to the general analogies of Nature. In proportion as this species of probability approaches to the certainty of fact, in the same degree will our hypothesis approximate to the nature of a firmly established theory, or, as it may rather be termed, a philosophical doctrine.

SECTION IV.

APPLICATION OF THE FOREGOING PRINCIPLES—ANALOGIES SUGGESTED IN FAVOUR OF THE THEORY—ELECTRICAL FLUID—THE SOUL.

I SHALL now endeavour to determine with what success the reasons which are offered in excuse of hypothetical theories, may be urged in favour of the speculation respecting a Vital Principle. As this is confessedly an hypothesis destitute of direct proof, I shall inquire, in the first place, what arguments, derived from analogy, or from collateral probability, can be brought forward in its behalf, and shall afterwards examine the explanations of phenomena which are furnished by it, when its truth is established or allowed.

Among the analogies adduced in favour of this doctrine, one has been already adverted to. I mean that of electricity, or the operations of the electric or galvanic influence. It must be confessed that this analogy is so vague and indefinite, as to afford scarcely a shadow of probable evidence. There is nothing in it of which the mind can lay hold, with a clear and distinct apprehension.

It may be expected that I should here advert to those remarkable experiments which have been thought by some to afford a proof, that the influence, which is exerted by the nerves of the living body over the muscular and other parts, takes place through the medium of the electric or galvanic fluid. According to this supposition, the brain might be regarded as a sort of Voltaic apparatus, and the nerves as conductors, which are continually galvanising the muscles and putting them into contractions, and thus moving about the limbs and the body by an electrical power acting in obedience to the will. But since it is not pretended that the nervous influence is identical with the vital principle, I may be excused from entering on a discussion of this subject at present, and I shall pass over it with the observation, that although the experiments alluded to are highly curious and interesting, they do not, in my opinion, authorize the conclusion, that the galvanic fluid is one of the agents by which the ordinary functions of the living body are carried on.

An attempt has been made to trace a still more remote analogy between the vital principle and the immaterial mind or soul. It has been suggested, that in the instance of the soul or mind, or principle of consciousness and intelligence, philosophers have been accustomed to concede the existence of an intangible and imperceptible agent upon inferential grounds, which yet, by some strict logicians, have been allowed to be sufficient to establish it; and a similar indulgence has been claimed in favour of the vital principle. Although I am of opinion that this remark is entitled to very little weight, and that no argument of any importance can be founded on it, yet, as the comparison to which I have last adverted has frequently been made, and as circumstances are likely to recall it and create difficulties, and perhaps some prejudice in the minds of persons who have not been accustomed to reflect on subjects of this nature, I think it will be advisable, before I proceed to consider the more important part of the argument in favour of a vital principle, to take a previous survey of the controversy respecting the existence of an immaterial principle or soul, the centre of consciousness and intelligence. We shall then be enabled to determine whether indeed any analogy or relation subsists between these two doctrines, and whether, if the one be established or conceded, it affords any degree of evidence, or even a presumption in favour of the other. And, if it should become fully evident that they are built on altogether distinct and separate premises, and that there is, in fact, no relation whatever between them, we shall afterwards proceed with some advantage, and move without prejudice, in prosecuting the inquiry respecting the vital principle.

Perhaps I ought here to offer some apology for entering upon the discussion of a subject on which I can scarcely hope to throw any new light. The line of argument which I have to pursue renders it necessary, and this will probably be allowed to be a sufficient excuse. In the observations which are to follow, I shall endeavour to avoid prolixity, and the obscurity in which metaphysical inquiries are too frequently involved; and in this I expect no great difficulty, since the main points on which the controversy between the materialists and their opponents really turns, lie in a small compass, and are easily to be comprehended. Indeed, it has been often and very truly observed, that whatever is valuable in science or philosophy, is in its nature lucid and intelligible, and that it is owing to the pedantry or needless obscurity of learned but unskilful writers, that so many things, in themselves plain, have been buried under a jargon of metaphysical subtilties and technical phraseology.

SECTION V.

REVIEW OF THE CONTROVERSY RESPECTING THE EXISTENCE OF AN IMMATERIAL PRINCIPLE, OR SOUL—METAPHYSICAL ARGUMENT.

THE strongest reasons adduced by philosophers, in proof of the existence of an immaterial principle, may be stated under two heads. The first may be termed the metaphysical argument, consisting, not of an attempt at demonstration, but of reasons derived from the nature of the human faculties and modes of thought. The second may be termed the inferential proof, or the argument by induction. I shall state both of them, in what I conceive to be their true bearing, and leave it to the judgment of others to estimate their merits, and to determine how far they are conclusive. I begin with the metaphysical argument, or with the reasonings on this subject derived from the nature of our faculties.

It has often been observed, that the whole sum of human knowledge may be divided into two departments, with reference to the channels through which it is acquired. The ideas, which belong to one of these departments, are originally acquired by perception, and through the medium of our external senses; those of the other class are revealed to us by our internal consciousness. The objects which are made known to us by the former, are the properties and affections of body, or matter; those which are shown to us by the latter, are the operations of mind. It is self-evident, that all properties whatever, must, as metaphysicians say, *inhere in some substratum*, or, in other words, they must be the qualities of some essence or substance; they must belong to something. The essence or entity to which the first set of properties belong, is, by common agreement, termed body or matter; that to which the second class belong, is named soul, spirit, mind.

It is a very important remark in this place, and in the argument which is to be stated, that of the two entities or substances now mentioned, matter and spirit, we have no knowledge whatever, except what is merely relative. We only know that such things exist, by inferring that they must exist, because their properties or attributes are perceived or felt. The essential nature of matter is utterly unknown, and the word means nothing at all, except that unknown substance to which certain known properties belong. Of mind or spirit we are equally ignorant, and the words mean nothing at all, but the unknown essence or substance to which another set of known properties belong. Algebraical symbols, such as x and y, would be just as expressive as these words, if there were only a general consent to use them for the same purpose. Those persons who have not been accustomed to examine accurately the limits of their knowledge, will not be prepared to admit that their ignorance is equal in these two cases. The remarks I have just made will, therefore, require some further illustration.

In the one case, indeed, I apprehend that there will be no hesitation or difference of opinion. All will be disposed readily to admit that we are quite ignorant of the essential nature of mind. Its properties or phenomena are made known to us by our consciousness, or internal feeling. These phenomena include all our intellectual operations, as perception, memory, judgment, or ratiocination, imagination, and the rest; all our emotions, grief, joy, pleasure, pain, passion; all the active propensities, or rather their conscious operation, belong to this part of our nature,——

> Quidquid agunt homines, votum, timor, ira, voluptas,
> Gaudia.

These phenomena are perceived by us with the greatest degree of certainty, but we have no information respecting the nature or manner of subsistence of that part of our being by which they are witnessed, and of which they are affections. We term it, from some of its known qualities, intellect, mind or *mens*, meaning that which knows or understands.

But those who have not reflected upon the subject, are disposed to imagine that they have a more distinct notion of matter, inasmuch as they feel and handle it, and appear to themselves to perceive its immediate contact with their hands and bodies. And perhaps the language of metaphysical writers, and of natural philosophers, is adapted to confirm this prejudice. For we find some ancient and many modern writers, distinguishing the properties of bodies into two departments, which they term the *primary* and *secondary*, and representing the former as essential to matter, or as arising necessarily from its substantial nature and constitution, and the other as accidental or contingent. In this it is obviously implied, that we are sufficiently acquainted with the constitution of matter, to be capable of making a distinction between qualities which are its essential attributes, and those which are not. The secondary qualities are colours, odours, tastes, sounds, temperature, and other properties analogous to these. Mr. Locke says, that "there is nothing like our ideas of these existing in the bodies themselves. There is in the bodies only a power to produce these sensations in us, and what is sweet, blue, or warm, in idea, is but the certain bulk, figure, and motion of the insensible parts in the bodies themselves, which we call so." But the primary qualities, hardness, or solidity, extension, figure, mobility, are conceived to be more essential to the bodies themselves. If the question were now asked, how can we determine that one set of properties are contingent or accidental, and that another set are essentially connected with matter, there would be two or three ways of replying to it. It might be said, that the essential properties are considered to be such, because they are universal qualities of all bodies, while the secondary are but occasionally manifested. But this was not really the circumstance on which the distinction was founded; for gravity, though it was long supposed to be an universal quality of matter,—an opinion which, however, ought perhaps to be subject to some limitations,—has not been reckoned among the primary qualities. The fact seems to be, that all those which are termed *primary qualities*, have been so considered, not on account of their being universal, nor because their existence was thought to be deducible from the real essence of matter, but because they are essentially included in our primary notion or idea of matter. This subject has often been discussed by metaphysicians and natural philosophers, but no where so well illustrated as in an essay written by the celebrated Dr. Adam Smith, and published among his posthumous works, by the late Professor Stewart. It has there been proved that figure, extension, and all the other primary qualities, are merely circumstances or conditions necessarily connected with what constitutes in reality our primary or principal notion of matter or of materiality, which is *hardness*, or the property of giving resistance to compression. This is the essential peculiarity in matter, which we fancy that we understand; yet it will appear, on examination, that we have no correct or distinct notion of its real nature. We are apt to suppose that hard bodies actually fill space, and that, owing to the natural impenetrability of their particles, it is in the nature of things impossible to compress them, or to introduce our hands, or any other substance, into the same spaces which they occupy, without displacing them. This, however, is in great part, at least, a mistake. For, without asserting that no such thing as actual contact exists between any two particles in the universe, or that the whole world might be squeezed into a nut-shell, we may easily collect from ordinary phenomena, that the cause of resistance to compression is not actual contact with hard and impenetrable substance, but something which repels bodies from the surfaces of each other, long before they come into contact. If any person attempts to compress air in a bladder, beyond a certain limit, he will find a great force necessary. Yet it is obvious that this does not arise from actual contact between the particles which are contained in this compressed air, or from their actually filling the whole space which they thus (if I may be allowed to use the most significant expression) *attempt* to occupy; it must arise from a mutual repulsion between the particles which act upon each other, *è distanti*, or when at a distance from each other. This cause being proved to exist, will be found sufficient to explain likewise the resistance to compression, or the apparent impenetrability of the densest and hardest solid bodies; for there are no bodies so solid, but that they might be further compressed, provided a sufficient force were used for the purpose. It is well known that the hardest bodies are contracted by cold, and expanded by heat. Their contraction proves that, although they are extremely hard, their component particles have not existed in actual contact. It has been ascertained, by electrical phenomena, that pieces of money lying one upon another are not in contact, and that the links of a chain, hanging freely in the air, do not touch each other, but are kept asunder by a repulsive power belonging to a very small surface, and acting in such a manner, that although the links support each other, they do not touch. This subject has been illustrated by Dr. Priestley, in his History of Discoveries in Electricity, and in some of his metaphysical disquisitions. I shall pass from it at present, after observing that the phenomena of apparent contact between solid bodies, and *more immediately* those of the impulse of solid bodies upon each other, seem to me to be best illustrated by reference to the reflection of luminous rays.

When a ray of light impinges on a polished surface, it is thrown back, as every one knows, at an angle determined by the angle of incidence. A similar phenomenon takes place, when a ball is struck against a wall, or the side of a billiard table. The phenomena are so similar, that we are justified in assuming that the same *cause* or *power* acts in both cases. Now it has been demonstrated by Sir Isaac Newton that the rays of light are reflected by a power of repulsion, acting at some distance from the surface of the body upon which the rays appear to impinge. As the ray is thrown back, without coming into contact with the polished surface, so, as it would appear, *is also* the ball, which seems to strike the side of the billiard table, rejected by a similar repulsive force.

Now if it be allowed, that, in the most solid bodies, the property of thus resisting pressure does not arise from the actual filling of space by impenetrable and inert particles, but from some active energy, which is exerted in repelling approach at a distance from the proper surfaces; and if we duly reflect, that of the efficient cause of this active repulsion we can form no idea,—the statement I have just given being merely a general description of the phenomenon, and not an attempt to explain the rationale of it,—it must, on the whole, be agreed, that we are entirely ignorant of the real constitution of matter, or of the cause from which the most universal and essential of its properties arise. All that we know of it is, that we witness certain effects, which we ascribe to particular qualities in external bodies, without having any notion of the connexion between these qualities, and the nature of that substance or entity to which they belong. The words body and mind, therefore, mean nothing more, as it was before observed, than we might express by x and y, taking x for the unknown thing, with which our feeling of resistance or solidity is connected, and y for the unknown thing, to which we ascribe the properties of sensation and consciousness.

If the preceding observations are allowed to be well-founded, we shall now be enabled to state, in a plain and intelligible manner, the controversy between the materialists, who deny the real existence of mind or spirit, and those philosophers who maintain it. The proposition set up by the materialist is, that these unknown substances, which I have termed x and y, are in reality but one and the same thing, though displaying two different sets of properties or qualities. This is denied by their opponents, who maintain that there are two distinct natures or entities, which, though sometimes brought into union, are essentially distinct from each other.

1. The advocates for this latter opinion, who are termed Immaterialists, or Spiritualists, remark, in the first place, that there is nothing, in the mode in which we become acquainted with these two classes of phenomena, that tends to favour the supposition that they belong to the same substance. On the contrary, we cannot contemplate them through the medium of the same faculty. One set of phenomena are only known to us, as I have already said, through the medium of our consciousness, or internal feeling; the other are objects of sensation and external perception.

2. If we attempt to compare these two classes of phenomena with each other, in order to determine whether they are of the same kind, and may probably belong to the same entity, we cannot discover the most remote analogy between them. On the contrary, there results from the contemplation of the one class, a notion which is quite irreconcilable with a notion that results from the contemplation of the other class. We cannot subject matter and its attributes to our examination, without

conceiving *it*, as well as the space which it occupies, to be in its nature infinitely divisible, or capable of separation and division without end. On the other hand, we cannot contemplate the phenomena of mind, or make the mental operations of which we are conscious the subjects of our reflection, without being irresistibly convinced that they belong to one being or thing, which is in itself absolutely indivisible. Our perceptions, recollections, thoughts, feelings, emotions of sorrow or joy, are all felt by us to belong to a self-same being, which we cannot, by the utmost effort of imagination, fancy to be divided into parts, or separated. We feel and know it to be a monad, a single and indivisible being. This is the only instance in which the qualities of one of these natures, or essences, can enter into any sort of relation with those of the other, and here they come into the relation of contrast.

These considerations are strongly in favour of the opinion that x, and y, the entity to which the properties of matter, and that to which those of mind belong, are distinct in nature. On the other hand, an attempt has been made, by a distinguished natural philosopher and a most subtile metaphysician, who may be considered as the greatest advocate of materialism in modern times, to prove that there is but one kind of substance or being in existence. The following is a short statement of his argument. We never witness the phenomena of mind, except in connexion with those of matter; therefore, the substance to which these two classes of phenomena belong, is one and the same. This is a clear and intelligible proposition, and it deserves a careful examination. If the assertion contained in it were established in its fullest extent, I do not perceive how, in the present state of our knowledge, we could avoid the inference. I shall cite the words in which this inference is drawn by Dr. Priestley, that I may not incur any risk of an erroneous statement.

"The power of sensation," he says, "or of perception, never having been found *but* in conjunction with a certain organized system of matter, (he alludes to the brain and nervous system,) we ought, as philosophers, to conclude that this power necessarily exists in and results from that organized system, unless it can be shewn to be incompatible with other known properties of the same substance."

This proposition is expressed in terms too limited for the argument with which it is connected; but, if we may be allowed to put it into a more general form, it will amount to the following assertion. Mental phenomena are witnessed by us, only in connexion with organized systems of matter; or, to speak plainly, we nowhere discover the manifestations of mind, thought, consciousness, intelligence, except in connexion with brains. Unless the proposition has this meaning, it has no force whatever in the argument; and, if it is received in this general sense, it holds out to the Spiritualist a challenge, which he may very safely accept. He may observe that the whole universe displays the most striking marks of the existence and operation of mind or intellect, in a state separate from organization, and under conditions which preclude all reference to organization. "The universal Mind," says a distinguished philosopher,* "though everywhere present, where matter exists, though everywhere moving and arranging the parts of matter, appears to do so without being united with matter, as in the case of visible, created beings." There is, therefore, at least one being or substance of that nature which we call mind, separate from organized body.

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* The late Professor Dugald Stewart.

This consideration affords a sufficient reply, if I am not mistaken, to Dr. Priestley's argument. If the phenomena of mind can be discovered, in one instance, in a state absolutely separate from organized matter, it is philosophical to conclude, when we find these phenomena connected with organized matter, with the properties of which they have nothing in common, that the connexion is accidental, or owing to some particular and temporary circumstances, and that it is not natural and essential.

SECTION VI.

REVIEW OF THE CONTROVERSY RESPECTING THE EXISTENCE OF AN IMMATERIAL PRINCIPLE, OR SOUL, CONTINUED— INFERENTIAL PROOF, OR ARGUMENT BY INDUCTION.

I NOW proceed to state, as briefly as I can, the second argument set up by those philosophers who maintain the existence of an immaterial mind, or soul, in the human being, and who contend that man is not *merely* a body, but a compound being, uniting a soul and body. The second argument is inferential. It is an attempt to prove that the phenomena of mind cannot, in conformity with the results of universal experience, be derived from the properties of matter, whether organized, or, in any imaginable way, modified. This inference is founded on a consideration of the various results which arise from different combinations and arrangements of material particles, from which the following statement has been deduced.* "In all combinations whatever of material parts, it is found that the powers or properties of the entire system, are nothing more than the sum or aggregate of the powers or properties of the component parts. Figure, magnitude, and motion, (in which last are included attraction and repulsion,) are the universal powers or properties of material particles; and, from the combinations of material particles nothing has ever been known to result, but some modification of figure, magnitude, and motion." It is, therefore, directly in opposition to the results of universal experience, to suppose that a combination of material particles can give rise to the phenomena, or constitute the operations peculiar to mind, or those feelings of which we are internally conscious. The contractions and lengthenings of cords or fibres, and the movements of fluid particles, will ever be something different in kind from the emotions of pleasure and pain, hope and joy.

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* Essays by Mr. W. Belsham.

This is a very brief and summary statement of a proposition, which it would require some space of time fully to develope and explain. Some persons may, at first, be inclined to question whether it is true, in fact, that in all combinations of material parts, the properties of the whole are nothing more than a modification or aggregate of properties belonging to the parts. It may be observed that, in chemical combinations, the compound body has often different chemical properties from those which belonged to the substances of which it was compounded; and that pieces of machinery display mechanical powers, which could not have been looked for in their parts when separate. Powers which do not come under either of these denominations, are likewise found to result from a combination of materials which, separately, possessed nothing analogous to them. An Eolian harp, composed of pieces of wood and strings, emits musical sounds; and an electrical or galvanic apparatus displays its peculiar properties, which nobody could discover in single jars of glass, or plates of metal. The reply to these objections is as follows. In the first place, with respect to chemical compounds, it is remarked, that all the properties of chemical agents resolve themselves into modifications of one property, *viz.* that of chemical affinity, or the generic or elective attractions of particles of various kinds for each other. This one property, from which all the operations of chemistry result, is modified, and, with respect to particular substances, increased or diminished by chemical composition, but still nothing new in kind is acquired, or can be imagined to be acquired, by any chemical combination whatever. In like manner, the mechanical powers, which are the results of machinery or construction, may be explained, without proving that any power new in kind has been generated. The operations of which the entire system is rendered capable, are nothing more than the obvious result of the joint operations of all the parts, and it is brought about by the compounded agency of their weight, density, elasticity, and other previously existing powers or properties, combined and set into action under particular circumstances. In the instance again of the Eolian harp, or that of the electrical machine, though these instruments are compounded of materials which, by themselves, possessed neither musical nor electric properties, still nothing new is produced by the fabrication, because a new agent is in reality called into play. In the one case, the air in motion or wind, in the other, the electric fluid, displays by means of the machine its well-known properties, and produces, by its peculiar movements, in the one instance, an agitation of the atmosphere upon our ears, in the other, an electric shock. On the whole, it is, perhaps, not too much to conclude it to be an universal fact, that the properties possessed by any aggregates whatever of material bodies, are not different in kind from the properties of the parts from which such aggregates were compounded, but are all resolvable into them. The inference which philosophers have drawn from these premises, in proof of the existence of an immaterial principle of feeling and intellect, is sufficiently obvious. The human brain, which, in a certain way, is instrumental in the operations of the mind, can only be an inferior organ or auxiliary, assisting the mind in the performance of its functions, as a crutch or a pair of spectacles assists a man in walking or seeing. Mental phenomena, as thought, feeling, volition, cannot be affections of the brain itself, which is an organized structure, composed wholly of insentient and inert particles of matter, because the former are phenomena entirely peculiar; and because powers or qualities, so diverse from those of the component parts, are never, within the sphere of human experience, found to be produced by any combinations.

To the apparent conclusiveness of this argument it has been objected, by some metaphysicians, that "the Creator, being omnipotent, *could* endow material particles, in a state of organization, with whatever powers it pleased him to bestow." This is granted by the advocates of an immaterial principle, but then they make the following comment upon it. If the powers bestowed upon any system of parts were such as did not result from any possible modification or composition of the powers of the parts, the endowing such a system with new powers or properties, *can, apparently,* mean nothing *else* than the adding to it of some new thing—some new entity possessed of such properties, or to the nature of which they have some relation; and this is, in fact, the very supposition with which the Spiritualist or Immaterialist sets out, *viz.* that an immaterial principle of mind or intellect is superadded to the organized structure of the brain.

I have thus endeavoured to give a summary of the arguments by which philosophers have endeavoured to establish the existence of a separate, sentient, percipient, or cogitative principle, distinct from the brain and nervous system, as well as from the whole organic structure of the body, but by the constitution of things capable at present of coming into relations with the external world only through the instrumentality of the bodily organs. How far these arguments are conclusive, I leave it to others to determine.

SECTION VII.

LIMITS OF THE SPHERE OF ACTION OF THE CONSCIOUS PRINCIPLE—ANIMAL AND PHYSICAL FUNCTIONS—LIMITS TO THE ENDOWMENT OF ANIMAL FUNCTIONS.

BEFORE we entirely leave the subject of the mind, or conscious principle, we must take occasion to observe that it comes in for a share in the performance of a certain class of functions reckoned among those of the body. Physiologists have formerly distinguished the functions of the living body, or the phenomena of life, into three classes, but they are now generally divided into two; these are, the animal and the physical functions. The former comprehends all those phenomena in the existence of living agents in which consciousness is displayed, or in which the mind, or conscious principle, co-operates. In these are included sensation and voluntary motion. The physical functions are those of which we are unconscious, as the circulation of the blood, nutrition, and secretion. If the existence of an immaterial principle is conceded, we shall be allowed to adopt an opinion, which removes many difficulties, and establishes a distinction of great importance to the further prosecution of this physiological inquiry. The immaterial principle, or soul, whose sphere of action comprehends all those phenomena connected with life *of which we are conscious*, and may therefore be termed the conscious principle, will be held to co-operate with the bodily structures destined for the respective functions of animal life. With the functions of physical life, of which we are altogether unconscious, this principle has no direct relation, and it is here that physiological theorists come in with their speculations on the vital principle. They argue that a principle of physical life is as necessary for explaining the phenomena of this, as a conscious and sensitive principle is for elucidating those of the former class. We shall presently come to the consideration of this opinion, after making a few remarks on the extent of existence and action assigned to the conscious principle.

There is one observation that will probably occur to some persons in this place, and to which a reply may be expected. It is, that in supposing the immaterial principle to co-operate with the bodily structures in the performance of all the animal or conscious functions, we are extending the endowment of such a principle to the brute creation.* That oxen have souls, may appear to be a ridiculous assertion, but everybody must allow that it is impossible to prove the negative; and the general proposition, that an immaterial principle is co-extensive with sensation, must be conceded by those who will allow that there is any conclusive force in the arguments which have been stated in the foregoing pages, for the existence of an immaterial principle in man. For, if organized matter alone is capable of sensation or conscious feeling, it is probably capable of all those other operations attributed to the soul; at least, no reason whatever can be alleged, on philosophical grounds, for the contrary. Sensation is an attribute of mind, and the possession of mind certainly extends as far as its phenomena. Whatever beings have conscious feeling, have, unless the preceding arguments amount to nothing, souls or immaterial minds, distinct from the substance of which they appear to us to be composed. If all animals feel, all animals have souls.

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* Whatever objections may be offered to this opinion must rest on theological grounds, and, perhaps, I might evade them by remarking, that the inquiry in which I am engaged is a philosophical one, and that I do not touch upon any theological consideration. But this reply might be less satisfactory to some of my readers than the observation, that by ascribing a sentient principle of an immaterial nature to the lower animals, I do not establish any thing from which it may be inferred that animals are destined to a future and immortal existence. The ancient philosophers held the eternal existence of souls, in their nature indestructible, which were to last for ever, as they had never begun to exist; but Christian divines have always maintained that the souls of men were created. What has begun, may cease to exist. There is, then, nothing in the

nature of souls, abstractedly considered, which precludes the supposition that if some survive the body, others perish with it; and this may be, if any one prefers to think so, the lot of the brute creation. The celebrated Bishop Butler has, however, suggested some reasons, which appeared to him to favour the opposite opinion.

Several authors have written treatises "de animis brutorum;" but I have nowhere seen this subject discussed with so much learning and ingenuity, as in a paper read before the Literary and Philosophical Society annexed to the Bristol Institution, by C. B. Fripp, Esq. The relations which the faculties of brutes bear to those of man, have been admirably illustrated by Dr. Hancock, in his Essay on Instinct.

But some of the lower orders of animals are suspected to be altogether devoid of feeling, and to be possessed merely of irritability, a property common to animals and to plants. This, as it is merely a modification of mobility, a capacity of being acted upon by external substances, in such a way as to occasion certain motions, without feeling or consciousness, is a property of mere matter, and has no relation to the nature or attributes of mind.

Naturalists are not entirely agreed on the question, how far, in the organized creation, consciousness and sensibility extend. The fanciful author of the Loves of the Plants, endowed the vegetable tribes with this principle, and, of late, it has been denied by some even to certain classes of animals. Lamarck, author of the "Zoologie Philosophique," and of other well-known works, has supposed that feeling is entirely wanting to zoophytes, which he accordingly terms "animaux apathiques," or apathic animals. His reason for this conclusion is the fact that no traces of nerves, or of a nervous system, have been discovered in creatures belonging to this department of the animal kingdom, though these organs are always present, where manifestations are displayed of the possession of sense and consciousness. And we are led nearly to the same conclusion by a remark of Baron Cuvier, founded on a different train of reflections. It is extremely improbable, as he observes, that sensation exists in any class of beings which are entirely destitute of the power of self-motion, because there would be no conceivable object or utility in such an endowment. "The beneficence," he adds, "which Nature has displayed in all her productions, does not permit us to believe that she has deprived beings susceptible of sensation, and conscious of pleasure and pain, of the power, in a certain degree, of avoiding the one and pursuing the other. Among the misfortunes which afflict our species, one of the most painful is, the situation of a man of courage withheld by a superior power from resisting oppression; and the poetic fictions best calculated to excite compassion, are those which represent sentient beings enclosed within immovable bodies. The sighs of Clorinda issuing with her blood, from the trunk of a cypress, would arrest the fury of the most savage of mortals."*

The considerations now adverted to, afford a convincing proof, to my own mind at least,

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* The fable to which Cuvier here refers, is in the poem of Tasso, who represents an unfortunate lady as imprisoned in a tree.

Flebile concento
Par d' umani sospiri e di singulti,
E un non so che confuso instilla al cuore
Di pietà, di spavento e di dolore.

Meanwhile, amid the foliage, sad and deep,
He heard the wind in ling'ring murmurs creep;
Thence issued soon, in mournful concert join'd,
Sobs deeply drawn and sighs of human kind;
On his roused soul a crowd of passions press'd,
Fear, pity, sorrow, sway'd at once his breast.

It may be amusing to remark that the same fiction is to be found in the two other Italian poets of greatest celebrity, I mean Dante and Ariosto. Dante has introduced it among the punishments of Hell, and I shall take the liberty of citing the passage, both from the original and from Mr. Cary's admirable translation.

Io sentia già d'ogni parte trar guai,
E non vedea persona che 'l facesse:
Perch' io tutto smarrito m' arrestai.
Allor pors' io la mano un poco avante,

that plants, and likewise those animals which are not capable of locomotion, are devoid of sensation; and perhaps this furnishes one instance of the successful application of the doc-

> E colsi un ramicello d'un gran pruno,
> E 'l tronco suo gridò, 'Perchè mi schiante?'
> Da che fatto fu poi di sangue bruno,
> Ricominciò a gridar: 'Perchè mi scerpi?
> Non hai tu spirto di pietate alcuno?
> Uomini fummo ed or sem fatti sterpi;
> Ben dovrebb' esser la tua man più pia,
> Se state fossim' anime di serpi?'

> On all sides
> I heard sad plainings breathe, and none could see
> From whom they might have issued. In amaze
> Fast bound I stood——
> Thereat a little stretching forth my hand,
> From a great wilding gather'd I a branch,
> And straight the trunk exclaim'd, 'Why pluck'st thou me?'
> Then, as the dark blood trickled down its side,
> These words it added: 'Wherefore tear'st me thus?
> Is there no touch of mercy in thy breast?
> Men once were we, that now are rooted here;
> Thy hand might well have spared us, had we been
> The souls of serpents.'——(*Infern. C.* 13.)

These poets were all admirers and imitators of Virgil, and they must have remembered the parallel passage in the third book of the Æneid, where a similar figure is introduced in the story of Polydore.

trine of final causes to physiology. It is common with philosophers of a certain class, who pride themselves upon being strict logicians, to disavow and treat with contempt all reasonings which refer to final causes, or, otherwise, to the apparent ends and purposes for which particular arrangements appear to have been adopted or contrived by Nature, or rather by Providence. For this they quote the authority of Lord Bacon, who can never have intended that such a construction should be laid upon his words. It must be confessed that the doctrine of final causes has been, on some occasions, strangely abused, and misapplied in a most ridiculous manner; as for example, by a writer on anatomy, who fancied that the os unguis, a bone near the inner angle of the orbit of the eye, was purposely made by Nature thin, in order that it might the more easily be perforated by surgeons in the operation for fistula lachrymalis. But the perversion of sound reason in the hands of weak and ignorant persons, is neither a new thing, nor does it carry any weight on the score of argument. We may safely conclude that the theory of final causes, or the inquiry into the beneficial results which arise from the arrangements of Nature, will never be laid aside in physiology, or in the study of the organized works of creation; for we cannot advance a single step without its aid, and it affords, when skilfully pursued, a species of evidence entirely convincing and conclusive, as far as arguments, derived from the most striking and extensive analogies, can be conclusive. Cuvier, throughout his works, has made a most happy and successful use of it.

I must now return from this digression, and conclude what I have to say for the present on the animal functions. I have already observed that a brain and nervous system are the instruments, through the intervention of which the mind receives impressions from material agents. The last organic changes which take place in the body, and from which the conscious principle immediately receives impressions, have their seat in some part of the nervous system; and in the same structure are situated those first movements which are immediately consequent upon the action of the will, when the mind re-acts and gives occasion to voluntary motion of the limbs. Of what nature those last movements are, as well as those which constitute the first link in the succeeding series, has been a subject of much discussion among physiological writers, but as yet no satisfactory information has been obtained with respect to it. On this subject, however, I shall offer a few observations, after concluding what I have to say on the doctrine of a vital principle, and the theory of physical life.*

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* See Supplement.

SECTION VIII.

OF THE APPLICATION OF THE HYPOTHESIS OF A VITAL PRINCIPLE TO THE EXPLANATION OF THE PHYSICAL FUNCTIONS.

FROM the survey which we have now concluded, of the sphere of agency ascribed to the principle of conscious feeling, it will be apparent what sort of analogy can be fancied to exist between it and the vital principle, which is supposed by some physiologists to be the agent in the functions of physical life. It is, indeed, only necessary to form a correct definition of these functions, or an intelligible limitation of their extent, in order to be convinced that the two principles in question, supposing, for a moment, that both really exist, are entirely distinct in their nature and attributes. We have seen that the faculties of animal life are those which bring us into relation with the external world, through the medium of sensation, and the consequent agencies of mind. The functions of physical life are those which contribute to the growth, nutrition, and support of the body, to the developement and conservation of its members, and its internal fabric. These are common, under certain modifications, to animals and to plants. There is nothing in them related to feeling or consciousness. The whole sphere of agency ascribed to the vital principle is, therefore, within the region of matter and its attributes; and if its existence is capable of proof, it must be on grounds totally different from those on which we have proceeded with respect to the existence and properties of a soul or immaterial being.

I have thus endeavoured to point out of what nature are the grounds of analogy and collateral probability which have been claimed by advocates of the doctrine of a vital principle. It still remains to examine the explanations which are furnished by its aid, of the principal phenomena of life. In entering on this undertaking, I shall, in the first place, consider the facts which relate to nutrition, or the functions by which the body is nourished, or supplied with new juices to repair its waste of substance, and shall survey, afterwards, the other processes which are most important in the animal economy, referring, in each instance, to the imagined interference of the vital principle, and to the circumstances under which its aid is suspected by physiologists to be required and interposed.

SECTION IX.

OF NUTRITION, AND HOW ELUCIDATED BY THIS THEORY—OTHER ATTEMPTS.

As all organized beings increase from a comparatively small bulk to a larger size; as in all of them internal processes are continually carried on, the effect of which is to dissipate a part of their component substance, it is evident that they must all be provided by Nature with some means of accretion or nutrition, by which they attract or draw in from without aliment to maintain a certain requisite mass or substance. The function by which this object is attained, is commonly termed digestion or assimilation, but this expression is scarcely applicable to the vegetable economy. Plants do not imbibe crude juices from the soil surrounding their roots, and again deposit those portions which are superfluous or noxious, as some have supposed.* The tubes of their roots appear to be endowed with the power of imbibing fluids from the soil with a species of selection, in consequence of which they draw in those matters which are salutary, and reject, at least to a certain degree, such as are insalubrious. This function in the vegetable economy would, with more correctness, be termed selection than assimilation. A property similar to it, appears to be likewise allotted to the organs which afford nourishment to animal bodies, for the lacteals are analogous to roots, and animals have been compared to plants with their roots turned inwards, and disposed round the sides of an internal cavity, into which they receive a mixture of materials. The ingesta answer a purpose analogous to that which is supplied to vegetables by a nutritive soil, whence the roots draw in appropriate fluids. But these materials require in the animal economy to be comminuted and dissolved; to undergo various processes of preparation, before the absorbent vessels can exercise their functions upon them. Such preparatory processes constitute the digestion or assimilation of physiologists. When they are complete, and when the alimentary matters are reduced to the state which is termed chyme, that function begins to be exerted upon it, which is analogous to vegetable absorption. The previous process has been termed chymifaction; it cannot by itself be styled digestion or assimilation; and if we were to adopt expressions for these phenomena, which should be universally applicable, we might term the first stage in the process of nutrition, *viz.* that which is peculiar to the animal economy, *Preparatory Solution;* and the last, which is common to the system of plants as well as to that of animals, *Nutritive Absorption.*

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* Wildenow.

The alimentary function, as it exists in plants and in animals, appears then to differ in these two circumstances. 1. Plants, not being locomotive, their absorbing tubes derive fluids immediately from the soil. But animals, as they are continually changing place, receive into an intestinal sac a portion of the nutritive materials, from which absorption is performed. 2. The component substance of plants consisting chiefly of carbon, hydrogen, and oxygen, their nutrition is more simply performed, as their aliment is easily obtained from the soil or the atmosphere. But animal substance being different, and consisting of a material more difficult, as it would seem, to separate from its adjuncts, those processes are required which reduce the aliment into chyme.

1. *Of the Preparatory Solution of the Food, or Chymifaction.*

The preparatory solution of aliment, or its reduction into the state of chyme or chyma, a semifluid substance of a cineritious colour, is performed by a combination of processes, partly mechanical and partly chemical. The mechanical part of the function may be traced easily, as the instruments provided by Nature for its performance are within our observation. The chemical, or solutive, process is more obscure; the agents are but imperfectly known by their effects, and hence there is room for the introduction of theories, some of which we must briefly examine.

It would be superfluous to go into a detail of the mechanical contrivances which Nature has adopted for the comminution of the aliment, or for breaking it down into small fragments, which may the more easily be acted upon by the solvent fluid afterwards employed. It is known that they consist of various methods, according to the nature of the food which the animal by its instinct is directed to seek. Teeth, in quadrupeds, effect this purpose by mastication; and the different forms of teeth, in relation to the principle just mentioned, furnish naturalists with one leading circumstance for the arrangement of animals into genera and families. In birds, which feed on hard substances, gizzards, aided by stones which Nature directs these animals to swallow, perform a similar office in the place of teeth. Some fishes have likewise thick and muscular stomachs, lined by a callous internal coat, which bear a remote analogy to gizzards.* The stomach of the ornithorhynchus hystrix is covered with a cuticle, and armed with sharp thorny papillæ, and the animal swallows sand, probably to assist in a similar grinding process.† Infinitely varied are the mechanical contrivances which comparative anatomy has displayed in the alimentary organs of different animals.

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* Blumenbach's Comparative Anatomy, translated by Lawrence, first edition, p. 147.

† Home in Philos. Transact.; Blumenbach ubi supra, p. 179.

It is after the aliment has undergone this mechanical comminution, that the process begins which physiologists have found it most difficult to explain,—I mean the conversion of the mixed assemblage of materials into an homogeneous fluid, which is termed chyme.

By many physiological writers of the last century, among whom one of the most celebrated was Dr. Cullen, the process of digestion was ascribed, in part at least, to fermentation, which was supposed to be either of the acetous or septic kind, according to the nature of the aliment. This opinion was founded on the observation, that the matters used for food are very prone to fermentation out of the body, and on some morbid phenomena. It was, however, fully refuted by the experiments of Spallanzani, which proved that the fluids of the stomach have both an antiseptic and an antizymic property. But it was Dr. Fordyce who first suggested the idea that digestion is to be ascribed to the vital principle, or to what are by him termed the living powers of the stomach. He observed that vegetable and animal matters, placed, out of the body, under similar circumstances, with respect to temperature, fluidity and mixture, to those under which they exist in the stomach, pass very speedily into fermentation ; and he conceived that there is a sort of constant struggle between the natural tendencies of these matters to ferment, that is, to form new compounds by virtue of their proper chemical affinities, and the forced changes induced by the action of the stomach. From these data he inferred that there is some peculiar chemical agency lodged in the stomach, which, like the other supposed operations of the vital principle, modifies the chemical affinities of the alimentary ingredients, and forces them to assume new compounds, different from those which the same matters are naturally disposed to form.

This hypothesis on the subject of digestion, exemplifies, in one particular instance, the physiological principles of Mr. Hunter, which are only followed up and somewhat extended by Dr. Fordyce. There is another view of the phenomena, founded on very different grounds, and connected with a method of reasoning which, to me, as I confess, appears a far more philosophical one. The theory to which I allude, may be termed the chemical and mechanical doctrine of physical life; not that it makes pretensions to the title of a complete theory, as does the system of Mr. Hunter, but because it purposes to explain the phenomena, as far as that is possible, by resolving them into the well-known agencies of matter in other departments of Nature, and, when anything occurs which is inexplicable on these grounds in the present state of our knowledge, leaves them for future investigation, in the hope that the knot will hereafter be untied, as many such knots have been, by the progress of discovery, rather than cut at once by a scheme which removes all difficulties, by resorting to the unknown operations of an unknown agent. With respect to the preparation of aliment, it seems, as we have remarked, to be partly a mechanical and partly a chemical process, like many others in the living body. To the mechanical part of it we have already adverted. The chemical, is a solution by the gastric fluid, which is merely a chemical agent, and acts upon the alimentary matter, when previously ground or comminuted, by virtue of the chemical affinities of its constituent parts. This fluid is secreted or poured out from the minute mouths of vessels which open upon the inner surface of the stomach. That the gastric fluid dissolves the aliment by its proper chemical agencies, and not by the aid of any peculiar vital energy exercised by the stomach or by the vital principle, we have sufficient proof from the well-known experiments of Spallanzani and Stevens, who have shown that the same or similar effects ensue, when animal or vegetable matters are subjected to the action of this fluid, out of the stomach.

2. *Of the Separation of Chyle.*

The function of the stomach is completed by the solution of the aliment, or its conversion into chyme, and the propulsion of this substance into the duodenum; and it is in the latter cavity that the separation into two portions, or what might be, in the exact meaning of the word, termed digestion, actually commences.

Physiologists have not agreed in their notions of the means employed by Nature for effecting the separation of chyle. Some have supposed that the bile and pancreatic fluids, which are poured into the same cavity, by mixing with the chyme, are the agents in this process; that they effect a decomposition of the chyme, and separate it into two portions, namely, the chyle, afterwards to be absorbed by the lacteals, and the residual matter, which is to be rejected from the intestines. But this opinion seems to be destitute of proof, and is attended with difficulties. How, it may be asked, supposing it to take place, does it happen afterwards that the lacteals receive into their mouths the chyle only, and reject the whole of the residual matter, which must likewise be frequently in contact with them, unless they are supposed to be endowed with a power of selective absorption? And if that property be conceded to them, it is sufficient to explain the whole process, without the intervention of any other means. It has been remarked moreover, and the observation seems conclusive, that the presence of bile cannot be absolutely necessary for the formation of chyle, because, in cases of jaundice, it is well known that the flow of bile has been entirely obstructed, for one, two, or more weeks, and yet the person so affected has not died for want of nourishment.*

It appears, on the whole, probable that the separation of the chyle is effected by the lacteal or absorbent vessels. These are projected from the surface of the small intestines by means of *villi*, which are productions of the internal coat, each provided with an artery, a vein, and an absorbent vessel. The latter terminates, with an open mouth, on the surface over which the chyme has to pass, and absorbs from it that portion of which chyle is to be composed.

That the absorbent vessels, which are termed lacteals, are endowed with a power of selecting certain portions from the chyme, or of absorbing those elementary particles which are nutritious and salubrious, to the exclusion of such as are noxious or superfluous, is a supposition which is not established by any direct proof. But it is an hypothesis which, if admitted, explains satisfactorily the phenomena ascribed to it. It is, moreover, supported, if

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* Young's Sketch of Animal Chemistry, Medical Litt. p. 516.

I am not mistaken, by an analogy in the function bestowed upon the roots of plants.

That the roots of plants imbibe fluids from the surrounding media, with a degree of selection, and that they do not draw in all indiscriminately, seems to be ascertained by a variety of facts and experiments. "Some philosophers have maintained," says Wildenow, "that plants imbibe from the ground earthy, saline, mucilaginous, and oily substances, and again deposit them. But plants do not deposit crude juices, which have not been wrought in the cellular texture. Were the case otherwise, a great quantity of ammonia, phosphorus, and other constituents discovered in animal excrements, would be found in plants reared in dung. But in corn, growing in a soil either plentifully manured or not manured at all, a greater or less quantity of these ingredients is never observed." Plants, again, which grow on a calcareous soil, do not imbibe lime in indiscriminate quantity; they are, indeed, found not to contain more of this element than those which grow in sand, or upon granite. It is well known likewise, that neither odorous nor colouring matters pass un-changed into the unwounded roots of plants, and that in order to accomplish the absorption of such fluids, it is necessary, by cutting the twigs, to bring the fluid into direct contact with the sap tubes.*

The experiments of Saussure prove that plants absorb saline solutions in very different proportions, and that the quantity of the saline matters which they imbibe, bears, in general, a very small ratio to the quantity of pure water which they draw in from such solutions.

When various salts were dissolved at once in the same solutions, and plants made to vegetate in them, it was found that different relative quantities of the salts were absorbed. In this instance it is remarkable, and contrary to the expectation which would have been formed *à priori*, that those saline matters which were absorbed in the greatest proportion, were precisely such as were found to be *most injurious* to the plants. Saussure supposed that the different quantities in which these substances were absorbed, depended rather upon the degree of liquidity* which the solution possesses, than upon any discriminating power of the root. But if this were the case, and if the root has no such power, it would be difficult, as Dr. Thomson has observed, to explain how so much greater a proportion of water should be absorbed, than of the salts which it holds in solution.† This last fact proves a selective power to be exerted by the root, which resists the ingress of an indefinite quantity of extraneous matter within its structure, and admits freely the water, which is the proper element for the nutrition of the plant. The reason why the more noxious saline substances were found to be imbibed in the greatest quantities, is probably the following. The process by which matters noxious to the plant are rejected, is perhaps one principal part of the function proper to the extremities of the root. When, by the application of noxious sub-

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* Decandolle and Sprengel's Elements of the Philosophy of Plants.

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[*] It is not very conceivable that such difference in the liquidity of saline solutions should really exist, or that a solution of sugar should be much more liquid than a solution of muriate of soda; yet the quantity of the former solution to that of the latter, found to be absorbed, was as 29 to 13. See Note I.

[†] Thomson's System of Chemistry, 1807, vol. 5.

stances, the energy is impaired by which these organs perform their office, substances enter in solutions which would otherwise be repelled, and the more noxious and destructive of the vitality of the parts these substances may be, the sooner the power of resisting their ingress is destroyed.

SECTION X.

OF SECRETION—HOW ELUCIDATED ON THIS HYPOTHESIS—OTHER ATTEMPTS.

NEXT to that process by which the necessary supply of blood, or of nutritive fluid, is provided for the system, Secretion is the most important function of physical life, both in animals and in plants. A great number of substances in animal bodies, different in kind from each other and from the blood, are produced or elaborated out of that fluid, by organs adapted for this particular purpose. This separation is termed *Secretion*. Of the great extent and importance of this function in the animal economy, we shall have an idea, when we reflect that not only all the fluids, except the blood, contained in or emanating from animal bodies, are the products of it, but that even the solid material and whole structure of the corporeal frame has been derived, in the first place, from the common nutritive fluid, by a secretive process, and is constantly maintained in its proper mass and quality by the same means. Every particle of which the muscles, and even the hardest bones, and the whole skeleton consists, has sometime circulated through the blood vessels, and has been deposited in its proper place by secreting vessels. The whole body may be considered, with accuracy and truth, as consisting of a frame-work of cellular texture, in which all the other parts lie deposited in the cells or interstices. The bones are nothing but earthy deposits within the cells of this membrane. The muscles, as well as the brain and nerves, consist of fibres encased and embedded within the same cellular texture. The deposition of these various substances, differing according to their situations, is effected by means of vessels which ramify over the cellular tissue, particular sets of vessels having the property of producing, out of the common fluid which is thrown into them in the course of the circulation, different and peculiar deposits. Thus we may observe, that when a bone is fractured and a part of its substance lost, a union between the divided ends is first formed by soft granulations, consisting of extensions from the previously existing blood-vessels and cellular tissue. After a soft union has been formed, in which nothing exists but the common cellular texture of the body with the vessels ramifying through it, these vessels, having their structure re-organized and completed, gradually recover the function peculiar to them in that part, and pour out, first, a substance termed callus, approaching to the nature of bone, and, when their action is fully restored, they deposit true bony matter, and a hard and perfect union is established between the divided extremities of the broken bone.

But it is the production of fluid deposits from the blood, that is most generally contemplated by physiologists under the term secretion. I shall not attempt, at present, to enumerate the different fluids which are produced in the state of health and in that of disease, but shall hasten to say a few words on the nature and office of glands, a term given by anatomists to the accumulated congeries, or masses of secreting vessels, which perform the separation of the most important fluids. Nothing was known concerning the nature of glands, till Malpighi, a celebrated Italian anatomist, undertook the investigation of their structure.

Malpighi's doctrine, as to the intimate texture of glands, is, that they consist of innumerable little follicles or sacs; that these little cavities are everywhere interposed between the small arteries conveying blood to the organ, and the vessels containing the peculiar secreted fluid. According to him, therefore, the artery of a gland conveys blood to a follicle or bag, and, after ramifying and encircling it, pierces it, and secretes the peculiar fluid into it, and there is an excretory duct, arising from the follicle, which conveys away the fluid.

The doctrine of Malpighi was afterwards opposed by Ruysch, a Dutch anatomist, who discovered, by means of fine injections, that the round bodies, supposed by Malpighi to be follicles, were merely very fine arteries convoluted. He concluded, therefore, that the small secreting arteries, after making their convolutions, terminate, without any cavity interposed, in the excretory vessel of the gland; or, in other words, that the artery conveying blood, and the vessel which is found to contain the peculiar fluid, are continuous tubes.

Anatomists are still undecided between the doctrines of Malpighi and Ruysch, or, rather, they are inclined to believe that both are correct in the instance of different secreting glands. But, if either of these opinions were fully and universally established, we should still want information as to the process of secretion, and yet be unable to form any distinct and precise notion by what mode or species of action this curious and remarkable phenomenon is brought about. It is necessary, however, for our purpose, to take a brief survey of the attempts of physiologists to find a solution of this difficulty.

The principles of chemistry, and those of mechanical philosophy, have been applied in this instance, as well as in many others, with too little care and discrimination to the processes of the living body. Chemistry could not properly be termed a science in the time of Paracelsus and Van Helmont. It was yet blended with the mystical speculations and vain practices of the alchymists, and animal chemistry was entirely unknown. It was from this time, however, that the chemical theory of secretion takes its rise, which Haller attributes to Van Helmont as its author. The first attempt to refer secretion to chemical agency, was the conjecture that it consists in fermentation. A ferment was supposed to exist in each gland, which, mixing with the blood stagnating in it, disposes that fluid to a chemical change of constitution, analogous to that produced in saccharine liquors, which are excited to fermentation by a small portion of yeast. The secreted fluid was supposed to be the result of this process; and it was remarked that these fluids differ as much from the blood, as vinous liquors differ from the sweet fluids out of which they are produced by fermentation. The laborious Haller has taken the pains to consider and refute this hypothesis; but it is sufficient to observe, that the supposition of a ferment in each gland is not only destitute of all proof, but is a most improbable conjecture. The attempts of the mathematical physicians were supported with greater ability, and have, with different modifications, maintained their ground much longer in the schools of medicine. It has been remarked, indeed, that there is no subject in the whole range of physiology, which appears to afford so much countenance to this mode of reasoning as the phenomena connected with secretion. It was supposed by Descartes,* that the glands contain a sort of filtering apparatus, and that some of the component particles of the blood are separated from the remainder, by passing through vessels and pores of a particular form: that the pores of the gland are so constructed, either as to shape or position, as to allow particles only of a peculiar size or figure to pass through them, there being triangular vessels capable of transmitting prisms, and square ones adapted for cubes. It was observed, in confirmation of this doctrine, that the vessels of each secreting organ pass off from the trunks, and ramify in a manner peculiar to themselves; a remark of which it would be easy to furnish several illustrative facts. A modification of this opinion was espoused by Leibnitz, and by the celebrated anatomist Winslow. It was observed, that wet or oiled paper will only transmit fluid of that kind with which it is imbued. It will not transmit oil when wetted, nor will water pass through it, when it has been previously oiled. Upon these facts an hypothesis was raised to explain the *rationale* of secretion. Between the secreting vessels and the ducts, in the tissue of which the glandular structure is composed, a fluid was imagined to be interposed, of that particular kind which is required to be secreted, so that when the blood is driven against the tissue thus imbued, nothing can be transmitted except particles similar in nature to those of the interposed medium.*

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* Haller's Elem. P. lib. 7, sect. 3, st. 29.

None of these speculations, for they scarcely deserve the name of theories, were found to be satisfactory, and they have long ago been superseded, especially in the English schools of anatomy and physiology, by a different hypothesis, *viz*. by that which ascribes all the most complicated and difficultly understood processes in the animal economy to the operations of a vital principle. This doctrine, as it is well known, originated with Mr. Hunter, whose opinions have directly or indirectly influenced most of the physiological writers of the last generation, both in England and on the Continent. The same fundamental ideas have undergone various modifications, but they are to be found, in one shape or another, in almost all the systematic works on the laws of the animal economy. The main difficulty which we have to encounter in explaining the phenomena of secretion, is that of finding a cause or influence capable of forcing particles to combine, which are less disposed to combine by their usual chemical affinities, or of separating bodies which are held together by strong affinity, in order to unite the component particles to other bodies for which they have a weaker attraction. This difficulty is solved by supposing that the vital principle imparts to the fluids of the body new chemical affinities. These new affinities are termed, by some writers, vital affinities, and they are thought to be different from the affinities of dead or inanimate matter.* Hence the component materials of the blood are disposed to form peculiar combinations, and we are thus to account for compounds produced in the glands, contrary, or at least not exactly according to the laws of ordinary elective attraction. The agent above mentioned is supposed to exert its influence over the particles of the blood, as they are circulating through the secreting organs, and by virtue of the new chemical affinities imparted by it, to give rise to peculiar separations and recompositions, and hence it comes to pass, that various fluids are elaborated out of the same homogeneous material in the different glands.

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* Newton has proposed, or, rather, has hinted at a theory of secretion, founded on mechanical principles, and, probably, not very different, if he had explained it, to those notions above stated. In noticing some facts depending on capillary attraction, he supposes them to be effected "by the same principle as sponge sucks in water, and the glands in the bodies of animals, according to their several natures and dispositions, suck in various juices from the blood."—*Optics*, book 3, query 31.

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* Plenck's Hygrologia corporis humani.

A complete refutation of this hypothesis was contained, if I am not greatly mistaken, in a single remark made upon it many years ago, by a learned and ingenious teacher of physiology in Scotland; and this refutation is the more convincing, as it proceeds by sufficiently proving that the hypothesis, if conceded, is wholly inadequate to solve the phenomena. The vital principle, it is observed, is, according to this hypothesis, the same element in all parts of the body, and it exerts its peculiar agency on the same material in all the glands. "How then," it is asked, "does it happen that different compounds are produced in the different glands; that the particles in the blood, separated from their old compounds and uniting in new ones, do, *under the same influence*, give origin to all the different fluids which are produced in the different glands?" In order to make the hypothesis coincide with this variety in the phenomena, it would be necessary to assume that there is a different vital principle existing in every different secreting organ; that there is in the liver a particular principle, which operates on the blood in such a manner as to give rise to the formation of bile; in the lachrymal gland, another which converts the same fluid into tears; in the kidneys, a vital principle which carries on the secretion of those glands. But if we are at liberty thus to multiply causes on mere conjecture, without end, it will be impossible to prove or disprove any thing. On the other hand, if we are to rest content with one vital principle, and are reduced to the necessity of asserting that one such agent is sufficient to perform so many and different operations, and that the difference in the results depends upon the variety in the structure and mechanism of different glands, the question has been asked, and it is likely to remain unanswered,—If the difference in the glandular structure and action is capable of giving rise to so great a variety in the products, with the cooperation of this one vital principle, how can it be proved that this difference in the glandular structure and action may not be capable of giving rise to that result by itself, and without the aid of any such adjunct at all? Thus it appears, on a consideration of the hypothesis, that there is no possible way of stating it, with reference to this particular function of secretion, that is not encumbered with difficulties greater than those which it is intended to resolve.

It would therefore appear that the student of physiology will be obliged either to give up entirely the hope of forming any idea of the nature of secretion, or to revert to the attempt of explaining it on chemical and mechanical principles.* The first efforts of this description were indeed inauspicious, but it by no means follows that the truth may not be discovered on the same path. The present state of our knowledge, either as to the intimate structure of glands, or the composition of the animal fluids, does not afford the means of clearing up this mystery. But the doctrine of the circulation was, for a long period, scarcely less involved in obscurity. Enough, indeed, was apparent to an ignorant examiner of the organs of circulation, to convince him that there must be some principle of mechanism on which their function was to be explained, but the nature of it was long sought in vain. And perhaps the glandular system displays so many phenomena indicating mechanical arrangement in the construction of particular organs, that we may presume the function of these parts to be in some degree dependant on their peculiar organization, though we have as yet no knowledge of the connexion between the structure of each gland and its mode of operation. At present, it appears more probable that secretion takes place through a combination of chemical and mechanical agencies. It has been said that an idea may be formed of the possible results of such combined agency, in the effect produced by milk agitated in a churn or leathern bottle. The mechanical movement of the fluid particles upon each other, places them under such circumstances with respect to each other, as to facilitate the aggregation of certain parts, and to produce a separation different from what ensues in a state of rest. And the difficulty of conceiving that new products may be formed from the blood, when the chemical agency of its component parts upon each other is modified by different circumstances, is very much lessened by an important observation, for which we are indebted to an accurate and judicious investigator of the laws of the animal economy. It has been remarked that there are many instances of bodies, both of vegetable and of animal origin, which are converted into each other by the operation of apparently slight causes, while we have likewise substances possessed of specific and distinctive characters, which yet seem to consist of the same elements, and almost exactly in the same proportion, so as to render it probable that a very minute variation in the affinities might originally have produced one or the other of them, or, after they were produced, might transform them into each other.*

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* See Note 2, at the end.

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* Dr. Bostock's Elements of Physiology, vol. ii. p. 398.

SECTION XI.

OF ANIMAL TEMPERATURE—DIFFERENT THEORIES.

THERE is perhaps no series of facts so well calculated to illustrate the manner of existence of organized beings, and the modes of continued action and re-action which subsist between their component structure and the surrounding elements, and which constitute the functions of physical life, as the changes induced on the blood, and likewise on the atmosphere, by respiration, together with the phenomena of animal heat. I mention the changes induced by respiration and the production of animal heat under one head, because these phenomena appear, notwithstanding some objections to this opinion, to be intimately related, and because, in the point of view in which I purpose to survey them, they must be considered in connexion. It is known that certain chemical changes in the atmosphere are induced by the presence of living bodies. It is known that living organized beings have the property of maintaining, within certain limits, an uniform degree of temperature, generally above that of the media in which they exist, implying an evolution of caloric. It is known, thirdly, that the chemical changes which the atmosphere undergoes from the action of living bodies upon it, are such as in all other instances are attended with the evolution of caloric. Lastly, it seems to be well ascertained, on taking a comprehensive survey of the functions of living beings, that the degrees of temperature peculiar to different tribes, or the quantities of caloric required to be evolved, in order to maintain the specific temperature of each, is in proportion to the extent of those changes which are induced by them in the state of the atmosphere. These considerations taken together, lead us irresistibly to the persuasion that there is a near connexion between the two processes in the animal economy, the comparison of which developes so remarkable a relation. But this conclusion will be placed in a stronger point of view, by a more particular statement of the facts.

In the first place, the most familiar facts in natural history are sufficient to establish a relation between the specific temperature of different tribes of animals, and the extent both of their organs of respiration, and of the consequent changes effected on the surrounding atmosphere. Nothing is more common than the division of animals into warm and cold blooded. The former class includes those tribes the whole of whose blood is brought, in the process of breathing, into communication with the air, or under circumstances which admit of its decarbonization, and the latter only such as have but a small portion of their circulating fluid similarly exposed. These last are likewise termed animals of a single circulation. Their specific temperature is generally but one or two degrees above that of the surrounding medium. On the other hand, those tribes, the whole quantity of whose blood undergoes the changes effected by respiration, have an uniform and a high degree of temperature. In birds, the organs of respiration communicate with large membranous air cells, occupying a great part of the thorax and abdomen, which cells, when they are compressed, force the air contained in them over the surface of the lungs. Their blood is consequently more extensively exposed to the atmosphere than that of other animals. Birds accordingly possess a higher temperature than that of the mammalia. The specific temperature of birds varies from 107 to 108, while that of viviparous quadrupeds is from 100 to 101.* Among animals which inhabit the waters of the ocean, an analogous difference is observable. Fishes, whose blood is but partially aerated in gills or branchiæ, by means of the air contained in the salt water, are cold blooded, and but little warmer than the sea; while the cetaceous tribe who breathe by lungs, and rise frequently to the surface for respiration, maintain a temperature several degrees higher than that of the human species, though dwelling in a colder medium.

A parallel observation may be made, when the same functions are compared under another point of view. It is well known that in the same given species the temperature bears a near analogy to the degree in which the circulation of blood through the body, and consequently through the lungs, is accelerated or retarded. When the heart beats feebly, and the blood is slowly transmitted through the system, and consequently through the pulmonary vessels, the skin and whole body are cold and chilly. Exercise, the use of stimuli, and, in general, whatever causes promote the circulation of the blood, contribute in an equal degree to restore warmth and vital heat. Generally speaking, the force and strength of the circulation are to be estimated with tolerable accuracy by the degree of heat perceived in the trunk and extremities. Facts connected with morbid and unusual states of the body lead to the same conclusion. In fevers and inflammatory complaints, in which the circulation is greatly accelerated, and the respiration rapid and frequent, the temperature of the skin is often several degrees above the usual standard. On the other hand, in the torpid state to which those animals are reduced which are said to hybernate, the respiration and the circulation of blood are so diminished as to be scarcely perceptible; and in these, the temperature, though at other times high, is so much lowered as to be but a few degrees above that of the frigid atmosphere which surrounds them.

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* Bostock's Elements of Physiology, vol. ii. p. 244.

It is, in the second place, well known that the modification which the atmosphere undergoes in respiration, is analogous to that which, in combustion and other processes, gives rise to evolution of caloric. This observation is applicable, with perhaps a few exceptions, to all tribes of beings. It was supposed by Dr. Priestley, that plants renovate the air, or produce a change in it of an opposite nature to that which is the result of animal respiration; but later experiments have shown that this opinion is erroneous, and that effects are produced by vegetation on the atmosphere, similar in kind to those which are occasioned by the respiration of animals. The principal of these effects induced on atmospheric air by respiration, is well known to be the formation of a large quantity of carbonic acid, by the union of oxygen in the air inspired with carbon extricated from the venous or purple blood. Now the union of oxygen with carbon, and the consequent generation of carbonic acid, is attended in all other processes in nature or art, with an evolution of caloric, or an increase of temperature. It has even been calculated by Lavoisier and La Place, from the result of experiments, that the quantity of heat produced by the union of carbon with oxygen in combustion, is equal to that evolved by the formation of the same quantity of carbonic acid in the lungs. Here, then, we have a source of animal heat proved to exist, and adequate to produce the result attributed to it. It is, therefore, unphilosophical to look for any other. Thirdly, the circumstances under which the temperature of the system is cooled, are such, on the whole, as confirm the opinion that the process of breathing is the source of animal heat, although this subject is encumbered with some difficulties. A short survey of these difficulties is necessary to our forming a clear conception of the subject.

Dr. Black, as I have before observed, was the first who announced the philosophical theory respecting the source of animal heat, of which I have given the outline, and he founded it on the two considerations already adverted to; first, on the relation which the temperature of animals bears to their respiration, and, secondly, on the analogy between the changes which the air undergoes in respiration, and those produced on it by combustion. From these data he inferred that the process of respiration is a kind of slow combustion going on in the lungs, and furnishing continually a quantity of uncombined caloric, which from that centre is distributed over the body.

It has been objected to this theory, that the lungs must, according to it, be much hotter than the rest of the body, in contradiction to the prevailing opinion, supported, as it appeared, by some experiments, that the blood is of uniform temperature in all parts. The attempt to obviate this objection, gave origin to the most splendid and elaborate theory ever constructed in relation to any subject in physiology, I mean the theory of animal heat, by Dr. Adair Crawford. This ingenious philosopher ascertained, by experiments of the most satisfactory evidence, that the capacity of carbonic acid for heat is much inferior to the mean of the capacities of carbon and oxygen gas. Hence it follows, that by the combination of these two substances, in the form of carbonic acid gas, a portion of heat must be extricated in a sensible state, which is proved to be sufficient for the supply of the system. But it was further supposed that the heat which is extricated by this chemical change in the air respired, immediately becomes latent in the arterial blood, and in this state is carried into the different parts of the body, without affecting the actual temperature of the lungs. This conclusion was founded on experiments which indicated that the capacity of arterial blood for caloric is greater than that of venous blood, or that arterial blood of the same temperature contains more latent heat than the same quantity of venous blood. From these positions, if they were really established, it would inevitably follow that the blood, while passing in the lungs from the venous to the arterial state, and still maintaining the same temperature, must absorb heat, and that this quantity of heat, which is here supplied by the chemical change effected in the air respired, being conveyed through the arterial system in a latent state, is extricated in the extreme vessels in a sensible form, precisely where it is required for the wants of the animal economy. The immediate cause of its evolution in this state is the conversion of arterial into venous blood, which then takes place, and which is supposed to reduce the capacity of that fluid for caloric.

The only improbable circumstance in this theory of Dr. Crawford is, the great difference in the capacity for heat which is represented by it to exist between venous and arterial blood, while the chemical composition of the two fluids are so nearly similar. A series of experiments by Dr. Davy, with reference to this part of the conclusions drawn by Dr. Crawford, have produced a somewhat different result. From Dr. Davy's experiments it would appear, that the capacity of arterial blood for the matter of heat, though probably greater than that of venous blood, is still not so much greater as to account for the phenomena supposed, by Dr. Crawford, to be connected with this difference. At the same time, these experiments materially lessen, if they do not entirely obviate the difficulties which lie in the way of Dr. Black's original hypothesis. This they do by proving that the actual temperature of arterial blood is considerably higher than that of venous blood; that the temperature of the left side of the heart is greater than that of the right side; and that the temperature of parts diminishes in proportion to their distance from the lungs and chest, the focus where heat is evolved, according to this hypothesis, in a sensible or uncombined state, by the chemical process of respiration.

In whatever form we receive this hypothesis, the foundations remain unaltered. These are, chiefly the fact that a sufficient and proportionate supply of caloric is afforded to the system by the chemical changes which the air undergoes within the chest, and the apparently uniform and undeviating relation that subsists between the specific temperature of each tribe of beings and the capability of their lungs, or the extent of their power of respiration.

We may, on the whole, conclude that those remarkable facts in the animal economy which are connected with the temperature of the body, or the evolution of animal heat, have been elucidated in a satisfactory manner by investigations pursued in reference to the ordinary laws of chemistry.* The vital functions, including the circulation of the blood and respiration with its connected result, the production of animal heat, display a variety of agencies, contrived and arranged with wonderful art, but in their nature strictly mechanical; they display also, as we have seen, a variety of chemical relations existing between living bodies and the surrounding elements, in consequence of which actions and reactions are continually carried on, tending to support the vital movements of the animal economy. The degree in which these important functions of life have been explained by a reference to the principles of mechanism and of chemical affinity, hold out a hope of advancing further on the same path, and of elucidating, by similar inquiries, various other processes, and possibly all the more recondite phenomena of animal existence.

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* See Note 3.

SECTION XII.

PHENOMENA OF THE BEGINNING AND THE TERMINATION OF LIFE—HOW ELUCIDATED BY THIS THEORY.

I SHALL now make some observations on the theory of a vital principle, as it refers to the phenomena of the beginning and the termination of life.

It seems to have been an opinion of the advocates of this doctrine, that the strongest hold of their system lies in the supposed explanation afforded by it, of the remarkable differences which are observed between the phenomena of the dead and the living body. The component matter, both of animal and vegetable bodies, is disposed, by the chemical affinities subsisting between its particles and those of the surrounding elements, to form new combinations with the latter, and thus gradually to fall into a state of decomposition as to its own substance. During life, there is some controlling agency which defends it against the influences of external elements; but its dissolution, or decomposition, manifestly begins to take place soon after death. According to the advocates of the doctrine we have been considering, there exists during life in the body, pervading every part, an elementary principle, or rather a highly attenuated substance, which, among its other singular and remarkable properties, has that of imparting to the constituent matter of the animal frame new chemical affinities, of suspending the usual affinities between it and the surrounding elements, and thereby protecting the living fabric from dissolution.* The existence of this peculiar agent is inferred from the explanation which, if the hypothesis be conceded, it has been thought to afford of a variety of phenomena, and from the implied supposition that these phenomena admit of no other satisfactory solution. But to this claim a strong objection has been set up, which has not yet been removed.† All the reasonings which have been brought forward upon this subject, proceed, as it has been observed, on the supposition that the component matters of the living and of the dead body are under the same circumstances, with no other exception than that of the imagined presence or absence of the vital principle. Without such a presumption, no conclusive inference could be drawn from a comparison of the different effects produced on the dead and living body by external agents. But this position will appear, on a moment's reflection, to be very far from the reality. The component materials of the dead and the living body are not existing under the same chemical circumstances, that is, in a similar manner subject to the operations of chemical affinity or elective attraction, either among the component particles themselves, or between them and the surrounding elements. Their condition in these respects is different, and it is even different to an extent which it is impossible to appreciate. In the living animal, all the fluid particles of the body which, taken together, constitute a considerable part of its entire mass, are continually in motion, at every instant changing their relative situation. They are not for a moment stagnating, or remaining in that state of rest which is favourable to new and spontaneous actions of the particles on each other.

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* Plenck's Hygrologia corporis humani.

† Mr. Allen, Lecturer on Physiology.

By the continual movement of fluids through every part of the solid material of the body, the same degree of heat is, nearly, maintained throughout; and changes of temperature, or accumulations of caloric, which are intimately connected with chemical actions, both in the relation of cause and in that of effect, are prevented from taking place. The blood is, moreover, perpetually receiving fresh supplies from the aliment and from the atmosphere; it is thus continually changing in its composition, by the addition of new matter from without, as well as by throwing off, at every instant of time, a part of its own mass into the surrounding medium. The texture and composition of the solids is also altered every moment by the accretion of new particles deposited from the blood, and by the absorption and excretion of such parts as are in a state which requires that they should be thrown off. An infinite variety of processes are carried on in every part of the animal economy, the tendency of which must be to interfere with and to counteract the order of those spontaneous changes, which would otherwise go on and bring about the putrefaction of the solid and fluid parts.

These facts, for they are facts and not suppositions, tend to explain, in a far more rational manner than the theory of the vital principle, the nature of that property lodged in the living body by which it resists putrefaction or dissolution, from the agency of external matter.

It has been thought by many writers, that a striking illustration of Mr. Hunter's doctrine is afforded by the fact, that the stomach has been found not unfrequently to have undergone erosion by the action of the gastric fluid on its coats. It has been supposed that, under ordinary circumstances, the stomach contains an agent sufficiently powerful as a chemical solvent to act upon and digest or dissolve its component material; but that, during life, its substance is protected by the vital principle against the influence of this fluid, nearly in the same manner in which the surface of the body is supposed to be defended against the agency of the external elements. There can be little doubt that this explanation of the fact is correct to a certain extent; that life is in some manner the cause which defends the stomach from solution by the gastric fluid. For the same reason it would appear that worms, and occasionally other living inmates of the alimentary canal, exist there without undergoing digestion. But the question is yet to be answered, in what way does life thus protect the stomach and other living matter from solution? And the most probable supposition is, that this is done through the medium of the functions, or active operations connected with the living state. There are two obvious circumstances in which the living state of the stomach differs from that which occurs after death. The usual provision of Nature for the protection of surfaces which are liable to be acted upon by acrid fluids, is well known to be the secretion of a lubricating and defending mucus. There is a mucous coat in the stomach destined, as it would appear, to a service of this same nature. While life continues, this secretion is performed, and it is probably increased in quantity, according to the necessity of the particular time; but it ceases with death, and then, if there happens to be an abundant quantity of the gastric liquor in the cavity, it has the power of acting on the coats now no longer sheathed and defended. Another difference between the living and the dead condition is, that the former is one of continual action; the fluids are not left in contact with the solids, so that they may act upon them, as they would do in a state of absolute rest. There is still a third circumstance connected with the phenomenon in question, which is perhaps more important in the explanation than either of those already alluded to, and which at any rate must not be passed over. The fact of the solution of the stomach by the gastric fluid, has principally been observed in cases of sudden death, which has taken place soon after food had been swallowed. The fluid is then secreted, as we have reason to believe, in considerable quantity, and perhaps it is chiefly at such times that it is secreted at all.* The quantity has probably a reference to that of the alimentary matter that is present, and which, being mixed up with it by the action of the stomach, immediately absorbs it, and combines with it. When this action ceases suddenly, it may come into contact with the coats of the stomach themselves.

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* I have lately seen an instance in which a large portion of the stomach had been thus dissolved, in a child who had died of hydrocephalus. It is rarely found in cases of death from disease, or at least from disease which affects the general condition of the secretions.

The theory of a vital principle has been applied in a different manner, to account for the phenomena displayed at the beginnings of life in animal and vegetable bodies, and to get rid of the mystery which attends the gradual evolution of organic structure from ova and germs. Here the vital principle is no longer considered as a chemical agent, but assumes the character of a plastic or formative power; it presides over and sets in action the different processes by which growth and organization are effected, gives form and modification to the component parts of the animal or vegetable body, and contributes afterwards, by a preserving influence, to the maintenance of its existence for a definite portion of time. On this doctrine, which has, at the first view, a plausible appearance, we have to remark, that it ascribes to a thing, which on the supposition is merely a species of matter highly attenuated, properties and agencies which belong to the highest power and the highest intelligence. We may, if we choose to do so, term the cause which governs organization and vital existence a plastic principle, but it is a principle endowed with intelligence and design; it is the *same principle*, and *one* and the *same agent* in all created bodies, since all are formed on similar and harmonious laws; it is, in fact, nothing more or less than the energy of the Deity, operating continually through the universe, in preserving and renewing the various tribes of beings, in a manner scarcely less wonderful than at the period when they were first called into existence. To ascribe to a material principle such properties, is to invest it not only with reason and intelligence, but with the wisdom and power of an omniscient Creator, who, if he works by second causes, cannot be conceived to endow them with his proper attributes. Such language is an abuse of words, and contrary to every maxim of philosophy.

SECTION XIII.

PHENOMENA OF MUSCULAR CONTRACTION AND THE COAGULATION OF THE BLOOD—HOW SURVEYED BY THE ADVOCATES OF THIS THEORY.

THERE is still another series of facts, holding a very important relation in the animal economy, which must not be passed over in a review of physiological difficulties. I allude now to that power in muscular fibres which is termed irritability or contractility, and to some other properties nearly allied to it. The phenomena of muscular action are, indeed, among the most mysterious processes connected with the physical functions of life; and if they do not furnish a pretence for calling in the aid of an hypothetical agent, it is because such an admission can be of little or no avail in explaining them, and not on account of any satisfactory results obtained in the ordinary methods of inquiry.

It will be unnecessary in this place to describe minutely the structure or function of muscles. It is well known that they consist of fibres, which have the property of contracting or shortening themselves on the application of various agents; such agents are thence termed stimuli, and the property of thus contracting is termed muscular irritability or contractility. These contractions alternate with a state of relaxation or of elongation; they are the principal causes of all the movements of living bodies, both voluntary and involuntary, internal and external. What is the efficient cause of this act of shortening in fibres, and in masses or bundles of fibres, is a question yet unsolved. It is evident that when the act takes place, the two extremities of the fibre or cord are brought towards each other; it is observed to swell out in the middle, and become hard; at the same time its surface is seen to be wrinkled or corrugated, and in deep furrows. But what is most remarkable, is the prodigious force with which the muscles contract, and the great weights they are found capable of raising in this state, while the same parts, after the power of contraction is lost by death, are torn asunder by weights very considerably less. This induces us to believe, as

Cuvier has observed, "that in the moment of action, the particles that compose a fibre, not only approach towards each other longitudinally, but that their cohesive attraction becomes instantaneously much greater than it was before; for without such an increase of cohesive force, the tendency to shorten could not, as it would appear, prevent the fibre from being torn." It is very difficult even to imagine what can be the nature of this momentary increase of cohesive force. The best, at least the most specious attempt to illustrate it, with which I am acquainted, has been offered by the distinguished anatomist above named. He supposes that a sudden but very slight change in the chemical composition of the particles constituting the fibre, is the immediate cause of the augmentation of power. "It must be admitted," he observes, "that nothing but a sudden change in their chemical composition could be capable of augmenting so quickly and so powerfully their cohesion. We are already acquainted with the prodigious force with which the particles of some bodies tend to assume a new situation, whenever their chemical composition is somewhat changed.

The best known example of this kind, is that which is furnished by freezing water. The loss of a little caloric disposes its molecules to condense into acute solids, and they assume this form with so much force, that they burst the sides of very strong vessels. The living and contracted fibre is not, therefore, strictly speaking, the same body, nor composed of the same chemical elements as the relaxed and dead fibre." The minute change of chemical constitution to which this increase of cohesion is ascribed, is imagined by Cuvier to depend upon the transmission to the muscular fibre, through the medium of the nerve with which it is connected, of a subtile fluid, analogous to caloric, or to the magnetic or the electric fluid. This additional hypothesis, however, has not been confirmed by the most accurate investigations, and there is no question in physiology which has been more diligently pursued, or has exercised the labour and talents of more distinguished men.

As usual, the advocates for the vital principle put in their pretensions, in the instance of this mysterious operation of the animal economy. Their hypothesis is applied here as in other cases, like a weapon ready to cut every knot, but capable of untying none. The difficulty is not in the slightest degree lessened by admitting all that is assumed by these ingenious theorists.

The only fact as yet discovered, which holds out the hope of elucidating the phenomenon of muscular contraction, is the intimate relation which appears to subsist between this operation and the chemical constitution of muscle. All muscular fibres consist of one animal substance, *viz.* that which is named *fibrin.* As the property of contractility is only found in parts which consist of this substance, and as all parts of the body which are thus composed have the same property, we are entitled to assume that there is some connexion between the chemical composition of these parts and their organic function. Some striking analogies have likewise been brought forward from the phenomena which are connected with the coagulation of the blood, to confirm the foregoing inference. I find them so clearly and correctly expressed in the late work of a distinguished chemical philosopher and physiologist, that I shall take the liberty of borrowing his account of them.

"If an animal in full health be suddenly killed, the muscles are firm and rigidly contracted, and they remain a long time without undergoing the process of decomposition; whereas, on the contrary, if death ensue after violent exercise, if it be caused by lightning or electricity, or by the operation of some kinds of poisons, the muscles are relaxed and soft, have lost all their contractility, and much sooner become putrid; and it is found that in all instances these two states or conditions correspond to each other, *viz.* the degree of contractility remaining in the muscle, and its tendency to putrefaction. As the decomposition of the substance of a muscle is obviously a chemical operation, and as it thus appears to be so intimately connected with its contractility, it was concluded that contractility is the necessary result of a peculiar combination of chemical elements. This argument in favour of the chemical theory has been also extended to the connexion that has been observed between the contractility of the muscular fibre and the coagulability of the fibrin of the blood. The greatest part, if not all those circumstances which affect the contractility of the muscle, are found to produce a proportionate and corresponding effect upon the coagulation of the fibrin. But the fibrin of the blood, it is said, is a mere chemical compound; any change in its coagulability must therefore depend upon an alteration in its chemical composition, and as the muscular fibre exactly resembles it in its chemical composition, and as there is a strong similarity between their respective properties of contractility and coagulability, so it is inferred, that the former must likewise depend upon a chemical combination."*

The relation which is thus to be traced between the loss of contractility in muscular fibres and their susceptibility of chemical decomposition, and likewise the analogies between these properties of muscular parts and those which belong to the fibrin of blood, were first pointed out by Mr. Hunter, who however reasoned upon them in a manner directly opposite to the obvious and natural one. Instead of seeking to explain the most recondite and difficult phenomenon, by comparing it with that which is more simple, he contrived to throw an air of mystery—or, if I may be allowed to use the term, of *bizarrerie*—over a fact not incapable of elucidation, by associating it with one complicated in its circumstances, and rendered still more obscure by his theoretical mode of describing it. The contraction of muscular fibres is an action peculiar to living parts: instead of seeking to investigate its nature, by comparing it with the concretion of fibrin, and thereby to gain an insight into the nature of vital actions, Mr. Hunter preferred to say that the blood itself, like the muscular fibre, is alive, and when it concretes, after being poured out of the vessels, he maintained that the fibrin performs a vital act; that like the muscular fibre it contracts, and as all muscular contractions imply the presence of a stimulus, and no other is at hand, this last action is said to be occasioned by the stimulus of death.

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* Dr. Bostock's Elements of Physiology, vol. i. p. 212. I must add to this citation, that the author does not consider this argument as conclusive in favour of the chemical theory.

SECTION XIV.

CONCLUDING REMARKS ON THE MERITS OF THE THEORY OF A VITAL PRINCIPLE—SURVEY OF OTHER OPINIONS ON THE CAUSES OF PHYSICAL LIFE.

It is now time to arrive at some general conclusion on the hypothesis of a vital principle, and its merits as a philosophical theory. Unless I am greatly mistaken, it will not be going too far to say, that it has been proved, by a careful examination, to be wanting in every characteristic of a legitimate theory. The cause which it assigns is taken up without proof, and with little or no support from collateral probability; and if its existence is granted, it is found quite inadequate to account for the phenomena of which an explanation is sought.

Many of those physiologists who have not adopted the theory of Mr. Hunter, have thought themselves called upon to find some other solution of the problem, in what life consists, or at least to give an explanation of the meaning which they have attached to the term. The celebrated anatomist Bichât was, I believe, the first to bring forward a definition, which has since been adopted by several distinguished writers, chiefly among the French. This definition is the most simple and obvious one that can be imagined, differing scarcely from the ordinary meaning of the word life in popular language. It regards vitality as made up of the aggregate or sum of the functions which resist death.* Life, according to this view of the subject, consists in a continual train of actions, which have no cessation or interruption until death takes place, the machine becoming impeded in the mutual operations of its parts, or its structure being worn out.

This is an intelligible statement, and might pass for a complete definition of the thing to be described, so far as a definition can be expected, if it were not for the circumstance that we are enabled to trace the beginning of vital action, and to perceive that the cause of vital action is antecedent to its manifestations. Seeds have life, in a certain sense, that is, they are susceptible of vital action, whenever the requisite conditions may be added, and they have this property long before the functions of life commence. Seeds are known to retain their vitality for an indefinite space of time, when secluded from those agents which give rise to germination, such as moisture, heat, light, and atmospheric air. It cannot be imagined that any vital action is going on in the structure of an undeveloped seed, which may lie hidden in the earth, or be kept dry in a box for many years, and be afterwards found capable of vegetating. Life, then, is not vital action, but the susceptibility of commencing such action when certain agents are applied, and of maintaining the same actions when they are once set up.

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* "L'Ensemble des fonctions qui résistent à la mort."

But this account of the matter, although it goes a step further than the definition offered by Bichât, and appears to come somewhat more nearly to the verbal truth, yet affords no satisfactory solution of the problem. And such a solution cannot be attained, unless we should be enabled to determine *in what* the peculiar susceptibility consists, of setting up the actions destined to take place under the required conditions. Perhaps the actual state of our knowledge scarcely enables us to form a decided opinion upon this subject; but it is difficult to escape from the persuasion that the vitality of the seed, that which it retains for years in itself without change or perceptible effects, consists merely in its *organization*, including under that term the condition of its constituent parts, as to their mechanical texture and their chemical properties. Against this opinion, which is by no means a novel one, objections have been offered, but these are perhaps on insufficient grounds. It is strongly supported by the consideration that there are not only great, but, if I am not mistaken, insurmountable difficulties attendant upon any other view of the subject that can be proposed. For what can be imagined to belong to a seed lying inert in the soil, but its organization?—or what else can be retained by one that has been kept for twenty years in a box, and is yet found capable of vegetating, when wetted or when planted in the moist earth? A more direct evidence in favour of the same conclusion is afforded by the phenomena themselves of vegetation, or the changes displayed when the appropriate agents are applied to the hitherto undeveloped seed. These agents are chemical ones; the effects to which they give rise are, as it is well known, in the first place, chemical effects. Under the influence of heat, moisture, and atmospheric air, or air containing oxygen, germination commences, and the saccharine principle is evolved. This is brought about by the chemical change which is effected in the constituent matter of the seed lobes. Carbonic acid is formed and heat is extricated, as in similar chemical processes taking place under other circumstances. That all this is the result of chemical agencies, and that vital action is not the operative cause, appears from the fact, that a change precisely similar takes place in dead vegetable substance, when it is exposed to the same influences.*

The next step in the series of changes in the germinating seed eludes our research. It is probably a mechanical one, consisting in the local movement of certain parts in the intimate texture of the seed, in the lengthening of fibres, and in changes in the relative position of the minute constituent organs.

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* Dr. Thomson has remarked, that in hay which happens to imbibe moisture, the same processes are exhibited; carbonic acid gas is evolved, oxygen is absorbed, heat is produced so abundantly, that the hay often catches fire. At the same time a quantity of sugar is formed, as in the

The processes which follow the developement of the young plant, the energies of vital action being now brought into play, are somewhat more within the scope of our observation, and they are confessedly among the most curious and striking phenomena in the whole compass of living nature. The cotyledons of the seed are first observed to enlarge and to become vascular; the plume then emerges from between them; it expands itself and is prolonged, with an invariable tendency upwards, destined to develope its structure into branches and leaves, while the radicle, assuming a contrary direction, is lengthened uniformly downwards, and seeks the earth to become a powerful root, and serve as the principal support and organ of sustenance to the

germination of barley in the process of malting. It is owing to a partial change of the same kind, that old hay is generally much sweeter than new hay.—*Thomson's Chemistry*, vol. v.

future herb or tree. The root sends out fibrous prolongations into the surrounding medium, but these filaments, as it has been repeatedly observed, extend themselves more rapidly and to the greatest length in whatever direction there is to be found a soil, although at some distance from the plant, which is capable of furnishing the most abundant aliment, imitating, as many naturalists have thought, the instinct displayed by animals.

All these phenomena evidently point to the operation of a much higher power than merely mechanical principles. They are undoubted manifestations of that designing Intellect, whose plans are perspicuously discovered throughout all Nature, but most strikingly in the organized parts of it. In what manner, by what instrumental methods, the governing Intellect operates in these particular processes, human observation may never be able to discover; but this is certainly a legitimate object of investigation, and it is by no means impossible that light may be thrown upon it by diligent research. At present, it can hardly be said that philosophers have proceeded much further in it than mere conjecture. Can it be supposed that the component parts in the intimate texture of the seed are organized, or constructed according to such a method or plan of preordinate arrangement, as to determine, on principles of mechanism, all the particular modes of its future developement, and to determine these, under the particular circumstances of external agency, by which, from the influences of the surrounding elements, the organized body is to be acted upon in the early stages of its existence? This is what the most probable conjectures, supported by the result of very ingenious experiments on the subject of vegetable growth, in its most remarkable processes, would induce us to believe.* But if these investigations fail us, we can only seek for an explanation of the wonderful phenomena of vegetable growth and existence,—infinitely diversified, yet always referring themselves to general laws or universal analogies,—by ascribing them more immediately to the constant superintendence of the Designing and Operative Cause, which is perhaps the sole real agent in every movement in the universe, either of an entire world, or of the smallest atom contained it. I am unwilling to recur to a subject on which so much has already been said in the preceding pages, but I must not here forbear to remark, that the hypothesis of a vital principle, as applied to the series of phenomena just now described, or to others that may resemble them, is quite inadequate to assist us in explaining them. A single intelligent principle in each organic being, acting by an energy and will of its

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* See Mr. T. A. Knight's Observations on the Causes which determine the direction assumed by the radicles and elongated plumules in vegetating seeds, (in the Philos. Tr. 1806,) and, particularly, Remarks in a Letter to Sir J. Bankes, "On the Causes which influence the direction of the Growth of Roots." Philos. Tr. 1811, Part II. The ingenious writer draws the following inference:—"In all the preceding arrangements, the wisdom of Nature, and the admirable simplicity of the means it employs, are conspicuously displayed; but I am wholly unable to trace the existence of any thing like sensation or intellect in the plants; and I therefore venture to conclude, that their

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roots are influenced by the immediate operation and contact of surrounding bodies, and not by any degrees of sensation and passion analogous to those of animal life."—"The writers who have contended for the existence of sensation in plants, have betrayed the weakness of their hypothesis, in adducing a few facts only which are favourable to it, and waving wholly the investigation of all others."—See also the experiments and observations of M. Dutrochet.

own, would be a scheme too visionary for the most imaginative, and would besides be irreconcilable with the harmony of Nature in all its parts. On the other hand, the idea of one universal plastic principle, a second agent under the superintendence of the Deity, would be merely a revival of that old and exploded philosophy, which had to boast, as its last advocate, the learned Cudworth, and which nobody in later times has been found either fanciful or bold enough to advocate.

The developement of forms, according to their generic, specific, and individual diversities, not less in the vegetable than in the animal world, can only be accounted for by ascribing it to the universal energy and wisdom of the Creator. But this is a subject somewhat different from that with which we are at present engaged, namely, the inquiry in what consists the state of life or vitality in seeds, or, to use a general expression, in the undeveloped rudiments of organized beings, in which no vital action, no movement or operation peculiar to living bodies has yet commenced. It seems difficult to escape from the conviction that it consists alone in organization, meaning thereby, the union of a peculiar mechanical structure of the bodies, with a certain chemical composition of their parts, of such sort and so modified, that changes first set up by chemical agents shall become the means of bringing on actions or movements in the intimate mechanism of those parts, which actions constitute the functions of physical or merely corporeal life.

SUPPLEMENT.

OBSERVATIONS ON THE INSTRUMENTALITY OF THE BRAIN AND NERVOUS SYSTEM IN THE OPERATIONS OF THE MIND.

SECTION I.

GENERAL REMARKS ON THIS SUBJECT.

The function of the brain, or the office it performs in the animal economy, as the instrument or the medium through which the mind becomes affected by external agents, and by which it reacts in giving rise to voluntary motion;—in other words, the connexion between the soul and the body, is a subject involved in the deepest mystery. The cause of this obscurity lies in the nature of things. In all the functions of physical life, as respiration, the circulation of the blood, digestion, although there are some questions relating to these processes which are yet unexplained, we can nevertheless trace some connexion between the result or the end attained, and the means provided by Nature for its accomplishment. But with respect to the animal functions, or at least to that part which the brain and nervous structure perform in them, the case is quite the reverse of this. For, if we were able to show precisely of what kind are the ultimate changes in the state of the nervous or cerebral structure, which immediately precede sensation in the mind, we should probably still remain unable to perceive the connexion between the mental phenomenon which results, and the instrumental operation which Nature has in some way or another connected with it. No relation or common property can be imagined by us, between any process of which fibres or organized parts are capable and conscious of feeling or sensation, and yet the one is, by the constitution of things, the universal antecedent of the other. We have not, therefore, in this instance, the advantage of surveying the whole train of phenomena in one connected point of view, in which a knowledge of the end might tend to throw light upon the intermediate links of the chain.

It is, perhaps, owing chiefly to the reason above assigned, that we are so little informed as to the nature of those ultimate organic changes which are the immediate antecedents or causes of sensation; and the same circumstances render it doubtful, whether our knowledge will ever be materially extended in this direction. In the meantime, it is interesting to consider what are its actual limits. There are many questions relating to the same subject, which have been discussed with various degrees of success, and it will repay our trouble to review the conclusions which have been, or which may be drawn, with more or less of certainty, or of probability.

I shall enter upon the consideration of these subjects, by alluding briefly to facts which evince that Sensation is universally connected with, and immediately dependant upon a certain change of state in some part of the nervous system. I shall, secondly, mention the different conjectures which have been proposed as to the nature of this change. After stating these conjectures, I shall next advert to the inquiry, in what part of the nervous system the changes in question have their local seat; whether, for instance, they take place in the extremity of a nerve, in the organ of sense itself, or in a common centre of the whole nervous structure. The question which will then remain to be considered is a more important and interesting one than any of the preceding, and will require a more attentive investigation. It is, whether organic changes in the nervous fabric are connected with, and precede, not only sensations, but also the appearance and recurrence of ideas in the mind, and whether, indeed, similar changes are instrumental to all the operations of the mind without exception, or only to certain mental processes, others being unconnected with any such antecedents; and, if this last supposition be correct, what are those mental operations which are thus to be excepted, and which the mind performs by its own agency, without the assistance of material organs.

SECTION II.

SENSATION IS DEPENDANT UPON CERTAIN CHANGES IN THE NERVOUS SYSTEM.

THAT the function of the nervous system is in some way instrumental to sensation, may be inferred from the fact that the signs or phenomena of Sensation, or Feeling, are coextensive with the endowment of nerves. On surveying the organized world, from the lowest to the highest order of beings, we discover the manifestations of feeling and of conscious existence, as soon as the nervous fabric makes its appearance; and we witness the increase of these phenomena, and their approach towards the perfect state in which they exist in the highest class of animals, in proportion as the nervous system is more and more fully developed. In those animals which display but simple rudiments of a nervous system, as in worms and molluscæ, the senses have but a very limited sphere; in insects, they have greater extent of agency; in vertebrated animals, they become four or five senses, analogous to the senses of man.

2. The probable inference is strongly supported and converted into certainty, when we survey the nervous expansions in the organs of sense, and contemplate the careful organization by which Nature has provided for receiving impressions from without, and for maintaining communication, by intervening cords, between the extreme parts and the centre of the nervous system.

3. An additional consideration, which of itself would amount to a strong argument, arises from the fact, that a morbid state in the nervous structure, in any part, is accompanied by a corresponding defect in the sentient power; and that a total obliteration of this power results from the dissection of a nerve, or from any other change, owing to internal or external causes, by which the continuity is interrupted between the extremity of the nerve and the brain.

SECTION III.

DIFFERENT CONJECTURES WHICH HAVE BEEN PROPOSED AS TO THE NATURE OF THE ULTIMATE ORGANIC CHANGES IN THE NERVOUS SYSTEM.

VARIOUS notions have been proposed at different times, as to the nature of those changes which immediately precede Sensation.

1. The older physiologists looked upon the brain as a sort of gland, destined for the secretion of an animal spirit, synonymous with the nervous fluid of later times; and this was imagined to circulate in an unknown manner in the nerves, and to be subservient to sensation. The entire want of proof, and the obvious improbability of this supposition, there being no accordance between the structure of the nervous system and the imagined function, will save us the trouble of entering into a further consideration of this opinion.

2. The hypothesis of oscillations will deserve a more attentive survey, since it has to boast of Newton for its inventor, and has

been adopted by Dr. Hartley, who made it the basis of his celebrated theory.

The following are the reasons on which Sir Isaac Newton founded his opinion that Sensation depends upon oscillatory movements in the fibrils of nerves.

"When a man in the dark presses either corner of his eye with his finger, and turns his eye away from his finger, he will see a circle of colours like those in the feathers of a peacock's tail. If the eye and the finger remain quiet, these colours vanish in a second minute of time; but if the finger be moved with a quavering motion, they appear again." On this fact, the following query is proposed:—"Do not these colours arise from motions excited in the bottom of the eye, by the pressure and motion of the finger, similar to those which at other times are there excited by light for causing vision? And when a man, by a stroke upon his eyes, sees a flash of light, are not the like motions excited in the retina by the stroke? And when a coal of fire, moved nimbly in the circumference of a circle, makes the whole circumference appear like a circle of fire, is it not because the motions excited in the bottom of the eye, by the rays of light, are of a lasting nature, and continue till the coal of fire, in going round, returns to its former place? And, considering the lastingness of the motions excited in the bottom of the eye by light, are they not of a vibrating nature?"

Newton says further, in another query—"Do not the rays of light, in falling upon the bottom of the eye, excite vibrations in the tunica retina; which vibrations, being propagated along the solid fibres of the optic nerves into the brain, cause the sense of seeing?"

This explanation was rendered more complicated and hypothetical by an additional conjecture, proposed by the same celebrated philosopher, who brought into the theory of Sensation the aid of his favourite ether, or subtile ethereal medium, to which he has attributed, in the form of queries, so many phenomena in Nature. He says—"Is not Vision performed chiefly by the vibrations of this medium, excited in the bottom of the eye by the rays of light, and propagated through the solid, pellucid, and uniform capillamenta of the optic nerves into the place of sensation? And again, Is not Hearing performed by the vibrations either of this or some other medium, excited in the auditory nerves by the tremors of the air, and propagated through the solid, pellucid, and uniform capillamenta of those nerves into the place of sensation? And so of the other senses."

Such is Sir Isaac Newton's conjecture. As to the hypothesis of an ethereal fluid, the medium of vibrations, we can determine nothing, and it is sufficient to say that it is destitute of proof. The vibrations, or oscillations in the fibres of the nerves themselves, may perhaps be detected, if they really exist; and, accordingly, physiologists have occupied themselves with this attempt. Haller carefully examined, with a magnifying glass, a nerve, while under the impression of a stimulus sufficiently powerful to throw the muscle into which the nerve entered, into violent contractions; but he could not observe the least movement in the nerve itself. The same result ensued when he applied a nicely graduated scale. Other experiments have been instituted with the same view, and have led to similar conclusions, which are still further confirmed by the consideration that no substance can be well imagined less adapted to receive or transmit vibratory or oscillatory motions, than the soft and pulpy fibre of nerve and brain.

Another attempt to discover the nature of the organic cause, or antecedent of sensation, is that of Dr. Darwin, who considered it to consist in an action of certain fibres, analogous to muscular fibres, performing contractions, and undergoing elongations, similar to the contractions and elongations of muscular fibres. These quasi-muscular fibres he imagined to be situated in the nervous expansions belonging to the organs of sense. He supported this hypothesis by suggesting a number of vague analogies between the laws which govern the muscular and nervous systems. But such analogies can be entitled to very little confidence, when we consider the vast difference of structure and apparent capabilities of action, which distinguish muscular and nervous parts. But to advert to the matter of fact, and to the question whether contractions really take place in the retina, and in other nervous expansions, on the application of stimuli,—it would appear, that if such things existed, they would scarcely fail in some instance to be observable; and, as no such observation has yet been recorded, we must wait until that shall have been the case, before we can determine anything in favour of Dr. Darwin's theory. We may, however, be allowed to make this remark upon it, that it is somewhat more in accordance with the general analogies and laws of the living system, than the theory of vibrations which was before mentioned.

There is still another theory of Sensation, which must be briefly mentioned in this place. It is, in fact, only a part of the hypothesis lately advanced, which ascribes all the functions of nerves to electric or galvanic influences. The evidence on which this hypothesis rests, consists in experiments which have been made chiefly by Dr. Philip, and in which it has appeared, that when a branch of the nerves distributed to the stomach has been divided, the office of that organ, as far as digestion was concerned, was supplied by transmitting to it a stream of the galvanic fluid. On the merits of this theory, as it applies to the whole of the phenomena, I shall not at present attempt to enter, and shall be satisfied with citing a conclusive remark made upon it by Dr. Bostock, that before the *electric hypothesis* can be established, it will be requisite to prove that *every function* of the nervous system may be performed by means of electricity. "We must not rest satisfied with its apparent action upon the stomach, which is at best a dubious case, as far as the operation of the nerves is concerned; we must show that volition can be transmitted by the electric fluid, and that this fluid is equally capable of stimulating the nerves of the involuntary, as of the voluntary muscles."

It appears, on the whole, to result from a survey of the different hypotheses proposed with a view to explain the action of the nerves and brain, that we are entirely ignorant of the nature of those ultimate changes on which sensation depends. All that we know respecting it is by inference, and extends only to the fact that some alteration takes place in the momentary condition of the organized parts, which is followed by phenomena displaying themselves in the mind; but in what those alterations consist, we know not, neither are we, to all appearance, in the way of making the discovery; and, if we could make it, there is no reason to believe that we should even then be able to trace any connexion between the operation in the nerve or brain, and the consequent affection of the mind.

SECTION IV.

WHAT PART OF THE NERVOUS SYSTEM IS THE SEAT OF THAT ULTIMATE CHANGE IN THE STATE OF THE ORGANIC STRUCTURE WHICH IS THE IMMEDIATE OCCASION OR ANTECEDENT OF SENSATION?

PHILOSOPHERS have regarded Sensation as belonging to some particular part of the nervous fabric. Newton, in the passages above cited from his queries, speaks of vibrations being propagated from the retina to the seat of sensation. The imagined seat of sensations is by physiologists termed the Sensorium Commune.

A variety of conjectures have been proposed in reply to the inquiry—where is the sensorium commune?—but none of them are satisfactory.

Descartes, as it is well known, fancied it to be in the pineal gland, which he regarded moreover as the local residence of the whole mind. The facts on which this opinion was founded were, first, that the pineal gland is a single part, whereas other parts within the cranium are double, or in pairs, in the two hemispheres of the brain. Secondly, Because gritty substances have been found in the pineal gland, in persons whose mental faculties have been disturbed. This is true, but it is also well known that the same thing has often been observed, when no such disturbance had existed. Le Cat supposed the pia mater to be the seat of sensation, a notion contradicted by every physiological principle. The hypothesis of Soemmerring is more ingenious, and deserves a few moments' consideration.

According to this excellent anatomist, the immediate organ of sensation is the fluid contained in the ventricles of the brain. This opinion is supported by the fact, that many of the nerves of sensation are to be traced into the immediate vicinity of the ventricles. The point of junction between the two optic nerves comes, for example, into contact with the fluid in the third ventricle, and, in quadrupeds possessing acute smell, the olfactory nerves are hollow, their cavity forming a continuation of the third ventricle. The acuteness of the intellectual faculties of children in the incipient stage of hydrocephalus, is also adverted to by Soemmerring, as affording support to his opinion. But, perhaps, the chief inducement to adopt this hypothesis was in reality the notion, founded entirely on a prejudice, that very attenuated matter approaches more nearly to the nature and properties of the soul, or spirit, or the sentient substance, whatever it may be termed, than denser matter. This we have no reason to believe. If the movements of material particles on each other, which is the only function that can be ascribed to particles of matter as such, can be thought to constitute sensation, or to be accompanied by consciousness, it is just as possible, for aught that can be shown to the contrary, that the movements of dense bodies should be attended with such a result, as those of rarer ones. In the rarest fluid, this movement can only be a change of relative position in a number of particles in a given space. Such movement results from the shaking of a bag or a box full of balls, a thing as remote from the nature of sensation, as the rolling of a stone. As there is no species of movement or operation of which large bodies do not appear to be susceptible equally with smaller ones, attenuated matter seems to be as incapable of being the actual seat of feeling, as the largest and densest masses.

Dr. Darwin maintained an opinion as to the seat of sensation, which was widely different from that of earlier physiologists. According to his hypothesis, sensation is the immediate result of an action which takes place in the organs of sense themselves, without any intermediate operation in the brain, or in any real or imaginary common centre or point of communication. The brain, according to Darwin's doctrine, is not the seat of sensation and consciousness, but acts as a sort of gland destined to separate a fluid which is subservient to the nervous function, and the cause of irritability both in nerves and muscles. He maintained that vision, or the act of perceiving visible objects, is the immediate consequence of certain changes in the configuration of the fibres of the retina.

There are various facts well known to physiologists, which seem to furnish strong objections to this opinion as to the locality of sensation. If any part supplied with nerves be punctured, while the communication of the nervous extremities with the brain subsists, the individual expresses a lively sense of pain; but if the communication with the brain is cut off, and the part then punctured, no pain ensues. The case is similar with respect to injuries of the spinal marrow. When the vertebræ are dislocated near the origin of the spinal marrow, the sensation of every part below the injury is lost, while sight, hearing, and the intellectual faculties remain uninjured. It is well known likewise, that compressions and other affections of the brain itself destroy sensation, and hence it seems reasonable to conclude, that sensation is performed through the intervention of the brain.

These considerations are sufficient to prove that the assistance of the brain is needful to the performance of that ultimate action on which sensation depends. They still do not prove that this act takes place in the brain. The ultimate change may possibly have its seat in the nervous expansion connected with the organ of sense, if it be only allowed that the brain performs some part in the process which is requisite to keep that structure in a state of activity.

Darwin extended his conclusion respecting the local seat of sensation to the theory of ideas, which he conceived to be in a certain manner a repetition of sensations. But the local seat of ideas, if such an expression may be tolerated, cannot be, as Darwin imagined, in the same parts which are the immediate organs of sensation; because these parts are liable to be diseased, and completely disorganized, without destroying the recollections derived from sensations. Milton assuredly retained the recollection of ideas obtained through the visual organs, after his sight had been destroyed by amaurosis. The organ which is the immediate seat of reminiscence, or, rather, of the physical processes which precede the mental phenomena of recollection, must be, as it would appear, beyond the nerve.

The opinion that sensation itself results rather from a process taking place in the organ of sense and in the nerve connected with it, than in the brain, derives additional countenance and support from the views which have been of late maintained by Gall and Spurzheim, respecting the anatomy of the nervous system. The essential principles in the anatomical doctrine of these writers have been stated to consist in the three following positions.* 1. That each pair of nerves forms a particular system. 2. That all these particular systems communicate in the medulla oblongata, or medulla spinalis. 3. That the brain, meaning both the cerebrum and cere-

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* See a Report on the Anatomical Doctrine of Gall and Spurzheim, drawn up for the French Institute, by Tenon, Portal, Sabatier, Pinel, and Cuvier. These celebrated anatomists, after a careful examination of the subject, gave their opinion upon the facts demonstrated or asserted by Gall and Spurzheim, and constituting their new doctrine as to the structure of the nervous system. In this Report, although the French anatomists have not confirmed all the positions assumed, yet they allow that many important points are established, and others rendered probable, while they state that some rest as yet merely on conjecture. The Gallian anatomy of the brain has nowhere been more clearly stated than in this Report, or better contrasted with the views and opinions of the older dissectors. It is observed, that, in the old system, the principal points of opinion were the following. First, that the cortical or cineritious substance of the hemispheres and cerebellum, being a vascular tissue, is a *secreting* organ. Secondly, that the medullary substance or fibre is a tissue of *excretory* vessels, or of conducting filaments. Thirdly, that all the nerves are emanations or productions from the medullary substance of the brain; that the medulla oblongata and spinalis is a larger fasciculus, whence the spinal nerves are produced in succession; that the cerebral nerves are productions from the medulla of the cerebrum. From this idea of the structure of the nervous system, it has been inferred that the cerebrum is a common centre of sensation and volition, the voluntary impulse descending along the nerve. Haller,

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indeed, says that medullary fibres can only originate from the brain.

In opposition to this doctrine, the system of Gall and Spurzheim represents the cineritious matter to be every where the matrix or source of medullary filaments; where-ever it exists, they are produced; wherever a medullary fasciculus crosses this matter, it receives new fibres. Hence the idea of the wholeness or integrity of the nervous system as one structure is done away, there being many different cineritious sources of medullary fibres. Thus the nerves issuing from the spinal column are considered as originating from the cineritious matter interspersed with the medullary in that column, and the different points of production are compared to the several spinal ganglia in the nervous chord of the lower tribes of animals,—a somewhat conjectural analogy; the cerebral nerves, so called, are represented as arising in distinct origins from the medulla oblongata, a conclusion which is allowed, except in the instance of the first pair; the brain and cerebellum are considered as only developements of similar fasciculi of the medulla oblongata, the brain being a production of those fasciculi called corpora pyramidalia, which, in passing out of the medulla oblongata, receives accessions from the cineritious matter of the pons varolii, thalami optici, and corpora striata, and the cerebellum in like manner arising from the corpora restiformia, reinforced by fibres from the corpus fimbriatum. These positions are allowed by the members of the French Institute in respect to the brain, bellum, instead of being the centre or origin, is a sort of appendix or diverticulum to the great chord. If these positions are allowed

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but they are not admitted in what regards the cerebellum. The two pairs of fasciculi thus originating, constitute the diverging fibres; they terminate in the expansions which folded up produce the convolutions of the brain, and from these expansions arise the medullary fibres which converge towards the middle line, and produce the commissures.

On this idea of the structure of the nervous system, which is a far more clear and imaginable account of it than any other, and which is, I believe, the only one that purports to contain any thing like a systematic description, I would beg to suggest the following remark. In showing that each medullary structure, arising from a particular cineritious origin, has one distinct office, this system coincides with a great number of physiological facts. But should not the whole brain, according to this view, have only one undivided function appropriated to it, instead of so many distinct offices as are given to the different phrenological organs? For the whole brain is originally only a developement of one particular fasciculus. Its being reinforced by additional matter, such as the converging and other accessory fibres, does not, according to the general analogies pointed out between this and other parts of the nervous system, occasion any diversity of function. If, then, the function of the whole brain is simple and undivided, what becomes of the phrenological doctrine of so many different propensities, separately lodged?

A translation of the Report of the French anatomists above mentioned, may be seen in one of the early volumes of the Edinburgh Medical and Surgical Journal.

to have been established, the brain, properly so termed, is entirely separated from the question, which refers to the seat of sensation. It will still be possible that sensation may take place in some particular point of the medulla oblongata; but the most probable opinion will be, that the process from which sensation results is actually performed within the particular nervous structure connected with each organ of sense.

SECTION V.

ARE ALL MENTAL PROCESSES INSTRUMENTALLY DEPENDANT ON CHANGES IN THE NERVOUS FABRIC?—SURVEY OF THE PHENOMENA OF THE MIND, WITH A REFERENCE TO THEIR CONNEXION WITH THE NERVOUS SYSTEM.

I. *Of Perception, Memory, Phantasy.*

THE mental phenomenon of Sensation is instrumentally dependant upon certain processes in the nervous system; but the similitude, between this and other mental phenomena, is not so great as to allow us to infer by analogy that all the latter are, in like manner, preceded by organic changes.

The mental affection which immediately follows sensation, and is often confounded with it, though it ought clearly to be distinguished, is Perception, or that change in the state of the mind by which we obtain a notion or apprehension of an object as actually present and affecting our organs.

The notions or ideas acquired by perception are recalled into the mind by associations; they are recognized or recollected, and the objects are apprehended as having been formerly present, or affecting our organs with sensation. They are then termed thoughts, or ideas of memory, or recollection.

Another modification of ideas or thoughts subsists, when the objects are *simply apprehended*, and neither conceived to have been formerly present, nor to be actually affecting our organs. It is under this form that ideas come into our minds, in what is called phantasy, or reverie; and this modification differs chiefly from that of dreams, in the circumstance, that, in the latter, the trains of ideas which occur are accompanied with belief of reality.

These different classes of mental phenomena differ from each other in obvious and important particulars, yet they have some degree of analogy. This may be inferred from the fact, that common terms are applied to them, both in philosophical and in popular language, such as ideas, notions, apprehensions, thoughts. The expressions so often used, that memory recals an idea, referring to a notion acquired by perception; that the fancy conjures it up, that it recurs in dreams; indicate that such an analogy is recognized. The same inference may be drawn, perhaps more satisfactorily, from the circumstance, that in various states of disease, these several mental affections seem to pass into, or actually assume the peculiar character of each other. For madmen mistake the images and trains of their phantasy or reverie for ideas of perception,* or of memory; and, in dreams, a transition nearly of the same kind takes place.

These considerations indicate that there is some analogy between the physical conditions of the phenomena just enumerated; and hence arises a presumption, that if ideas are first produced in the mind by an operation in the organic structure of the brain, an organic change somewhat similar is the medium by which they are recalled. If this be granted, it will scarcely be disputed that a similar relation probably exists between the phenomena

* So the lunatic in Horace,

——— Fuit haud ignobilis Argis,
Qui se credebat miros audire tragœdos,
In vacuo lætus sessor, plausorque theatro,
Cætera qui vitæ servârat munia recto,
More——

of reflection or memory, and those of phantasy, reverie, or dreaming; that operations in the brain, if connected with the former, are also essential to the latter class; and that the organic changes belonging to each are nearly allied in their nature.

I shall now advert to some facts which indicate that ideas in the mind are, in many instances, from which we may perhaps be allowed to draw a probable inference that they are in all instances, preceded by some organic change.

I shall find no difficulty in establishing this inference, in so far as it relates to ideas of recollection; and the analogies above pointed out, allow me to draw a general conclusion, involving the other faculties already mentioned.

Pathological facts occurring every day prove the memory to be dependant upon the brain. There is scarcely any disease of the brain, of long standing, which does not impair the memory.* Partial and particular losses of memory are more striking than general failures, because they are not quite so frequent; and of these, the most remarkable are such as occur suddenly from the effect of accident, or disorders of rapid accession.

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* I have stated some facts in illustration of this remark, in the introductory part of my work on Diseases of the Nervous System, to which I beg leave to refer.

It is well known, that persons who meet with injuries of the head, are often found, when they begin to recover, to have lost all recollection of circumstances which had immediately preceded the accident; as their health is reestablished, the lost trains of ideas are gradually restored.

Hence it appears that ideas very recently impressed on the memory are more evanescent than those of longer duration, and more easily lost in consequence of injury to the cerebral organization. It is owing to the same fact, that individuals who had recently become acquainted with some particular language, have entirely lost their late acquisition, while they retained the rest of their knowledge.

The following fact, which I relate on authority deserving of the highest credit,* proves that, in some instances, after a long and very perfect oblivion of certain trains of ideas, the recollection of them may be restored, the brain having recovered its healthy condition, and becoming capable of setting up again the series of organic operations with which those ideas had been connected.

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* This account, which is given more fully in my work on Diseases of the Nervous System, was related to me by Dr. Stock, of Clifton, who received it from Dr. Rush, of Philadelphia.

A young man who was a student at an university in the United States, had made a considerable progress in classical learning, when he was seized with a severe fever which affected his brain, and, on his recovery, he was found to have lost entirely the share of classical knowledge which he had acquired, and was obliged to begin again, by learning the accidence in the Latin grammar, which was now quite new to him. He persevered with laborious diligence, and his toil was rewarded; for one day, when he was making a strong effort to repeat a portion of his daily lesson, he suddenly recollected all that he had previously learned, and found himself at once able to read the Latin authors; the whole of his former knowledge reappearing to his mind like a forgotten dream.

It is very remarkable that, in some cases of disease affecting the brain, and suspending or obliterating the recollection of ideas acquired in a recent period, by rendering the organic structure incapable of the operations connected with them, it has appeared that the state of morbid excitement induced by the same cause, has restored other trains of action which had long been effete, or had entirely ceased, and has consequently brought again before the mind the ideas formerly associated with them. Thus it has been repeatedly observed, that aged persons nearly at the point of death, have spoken in languages which they had learned in their infancy, but had for a long course of time altogether disused and forgotten. And there are a variety of cases standing upon authentic record, in which a similar phenomenon has taken place under severe disease affecting the brain. During the stupor or delirium attendant upon febrile complaints, many individuals have been heard to speak in languages which they had once known, but which had been previously obliterated from their recollection.

On reviewing the foregoing remarks, we are, if I am not mistaken, justified in concluding that the appearance of every idea in the mind is, probably, connected with, and is the consequence of, a certain previous operation in the organic structure of the nervous system. As that phenomenon, which we term sensation, is uniformly preceded by a certain change in the material organ or nervous fabric, so the appearance of ideas in the mind, whether of perception, a mode immediately consequent upon sensation, or of memory, or phantasy and dreaming, probably requires the instrumental aid of processes carried on in some part of the same organic structure. It is probable that no idea passes through the mind, without some concomitant, or rather previous operation of the nervous system, or some change in the momentary condition of the nervous fabric. The organic action of the brain seems to be as requisite to the recalling an idea into the mind, as the movement of the string of a harp is to the generation of a corresponding musical tone.

These considerations will, perhaps, throw some light upon the association of ideas; at least, they connect this phenomenon with a series of facts which physiology has rendered well known to us. It is understood that the law of association prevails very extensively in the actions of corporeal organs; indeed, the functions of life could not, as far as we can apprehend, be sustained without this regulation in the animal economy, and it must be considered as one of the laws of our organization. But in the philosophy of mind, the fact alluded to is less obvious in its relations; and so remarkable a coincidence induces a suspicion that the latter phenomenon is resolvable into the former. Now, the mental phenomenon of the association of ideas, may, in reality, be resolved into the fact which is to be traced in the bodily constitution, and may thus be simplified and generalized. We have seen that a certain action in the nervous system is the necessary precursor, the physical cause, or material instrument by which every idea is called up in the mind. Such actions in the nervous fabric are, like other corporeal movements, associated; those which have already taken place simultaneously, or in sequence, have a tendency to recur in the same combination; this is exactly analogous to what prevails in all the functions of the body; the actions of the brain recurring in this manner, call forth the mental ideas with which they are severally connected, and thus the law of association, which is properly a law of the corporeal functions, has its sway over the mind.

II. *Of the Emotions.*

There is another class of mental phenomena distinct in their nature from ideas, as well as from sensations, which are the results of ideas and sensations, or are brought into the mind in their train, or as their immediate sequents. These are the emotions, or passions and affections, sometimes termed, in popular discourse, "the feelings."

This class of phenomena includes pleasure, pain, joy, exultation, hope, fear, sorrow, regret, remorse, surprise, wonder, all those emotions and inward feelings which constitute the happiness and misery of human life.

All these phenomena are commonly classed among the active powers of the mind, very improperly, because the mind is equally passive in experiencing them, as it is in becoming the subject of sensations, and in receiving ideas which are recalled by association. All these emotions take place, without any active or spontaneous exertion.

We have already found reason to conclude that, before any sensation is felt, and likewise before any idea makes its appearance in the mind, or is the subject of mental apprehension, a previous instrumental change in the nervous fabric is necessary. We have now to inquire whether an instrumental operation in the same structure, or in any bodily organ, is likewise the precursor or physical cause of emotions; and, if so, what organized parts are the seat of this instrumental operation.

The ancients referred the intellectual faculties to the heart; and Galen found it necessary to prove, with some pains, that the organs with which they are connected are seated in the head. Some modern writers proceed much further, and refer the emotions and affections to the head.

By popular opinion, the passions and affections have generally been referred to the viscera, as many expressions in all languages will testify, such as, a good and a bad heart, bowels of compassion.

It is not difficult to account for these expressions, and to trace the notions connected with them to their cause. It is evident that they originated in the powerful effects produced on the internal feelings and functions of the body, by all vehement emotions. A loss of appetite and sickness are often the result of mental distress, or a sudden shock. Anger, anxiety, despondency, all have their appropriate effects on the stomach, liver, or intestinal canal. Palpitation or fainting, is the consequence of sudden terror.* The supposition was very obvious and natural, that these passions have their seat in the parts which are felt to be so powerfully affected by their operation.

These notions respecting the locality of the passions, are very vague and undefined. Physiologists have attempted to render them more accurate, without abandoning the foundation.

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* A quaint epigrammatic sentence, founded on this circumstance, has been preserved from a lost comedy of Anaxandrides of Rhodes.

Ω πονηρὰ καρδία.
Ἐπιχαιρεκάκον ὡς ἔι μόνον τοῦ σώματος·
Ὀρχεῖ γὰρ εὐθὺς ἦν ἰδῆς δεδοικότα.

"O malicious heart! thou alone in all the body rejoicest in evils, for thou leapest whenever thou seest one seized with terror."

Bichât conjectured that the ganglions of the great intercostal or sympathetic nerve, which are dispersed among the thoracic and abdominal viscera, are the seat of these phenomena. But this supposition, improbable in itself, is refuted by the fact, that the same emotion will display its effect on different organs in different individuals. Fear or terror will occasion in one person fainting, or palpitation of the heart; in another, it affects the liver or intestinal canal; but the particular effect would probably be uniform and unvaried, if the mental emotion were dependant on some particular ganglion of the great sympathetic. The vagueness of popular language on this subject is sufficient to prove that the physical effects of the emotions are very various. The Greeks referred most of the passions to the liver, spleen, and diaphragm; the Hebrews, to the bowels and reins; the Moderns refer them almost solely to the heart.

The diversity of these phenomena, which vary according to the peculiarities of constitution, proves that they are secondary effects produced by the emotions through sympathy on the functions of the viscera, those organs being most affected, which in each individual have the greatest irritability or susceptibility of impressions.

Later writers have abandoned the notion of Bichât, and have referred the passions to the brain. But this supposition is equally gratuitous, and supported by no proof.

The propensities, appetites, desires, aversions, are, in some respects, analogous to the emotions, and are generally associated with them by metaphysical writers. The remark I have just made on the former, is equally applicable to the latter class of phenomena. These may all be reduced to the desire of pleasure and aversion to pain; and I have not heard that any physiologist has been so ingenious as to discover the site of these phenomena in the brain, cerebellum, or solar plexus. They are constant laws of Nature through the animated world, or principles of action impressed upon all conscious beings. If, indeed, any one should choose to assert, that the instincts of a butterfly or of a beetle reside in its nervous chord, and the pride and ambition of Man in his spinal marrow or brain, we should not be able to refute the assertion, but the task of proving it lies upon him who ventures to make it.

III. *Of Volition, and the active Operations of the Mind.*

In all the preceding phenomena the Mind is passive; impressed by surrounding objects, it experiences sensations, which leave vestiges of their existence in ideas. Ideas are subsequently recalled in groupes and certain trains, by causes operating without or within the mind, and excite emotions differing according to the nature of the ideas. In all this the mind is, in some respects, as passive as a plant or a polypus.

But there is another class of mental phenomena in which the case is widely different. I allude to the active or voluntary exertions of which the mind is capable. In these, it is sometimes said, that the mind reacts; an expression of doubtful propriety, since it tends to impose upon us, by pointing to some analogy between mechanical reaction and the operations of the mind. It has often been remarked that, while reaction is equal to the force impressed, the will, when roused to action, operates with a degree of power by no means commensurate with the force applied; as when oxen, touched by a whip, move a waggon. In the inanimate world, there is an equality of action and reaction; but the will, as inciting the voluntary muscles, becomes a source of new action. The use of terms borrowed from inanimate processes has introduced much error into the philosophy of the mind; and, perhaps, if such expressions as motive, reaction, cause and effect, had not been thus adopted, we should never have heard of some celebrated theories, which have been, and still continue to be supported by the most distinguished philosophers and metaphysicians.

In the series of mental phenomena now to be considered, an action commences in the mind by an internal exertion of which we are conscious, and which is only recognized by consciousness; this is termed a volition. It is succeeded by other trains of phenomena, different in kind, according as the voluntary act is directed towards the body or the mind. In the former case, it sets in motion the voluntary muscles and limbs; in the latter, it puts into operation certain powers of the understanding. It is this class of mental powers which ought to be distinguished as the voluntary powers.

The voluntary powers of the mind, or those which are put in exercise by the will, are judgment, reflection, ratiocination, imagination, and the like. In all these, contrary to what is observed of sensation and memory, the mind is in a state of activity and exertion.

Before I proceed further into this subject, I would advert to the question,—how the act of volition itself is performed, and in what division of our compounded nature it has its seat and origin? We have seen that in the passive affections of the mind, when sensations or recollections are called forth in it, there is a previous change in the bodily organization; the affection of the mind is the consequent phenomenon: but here the order is perhaps reversed; the mind acts upon the body in voluntary exertions; it sets up or begins action, and it is probably in the mind itself that the act of volition takes place in the first instance, and the connected organic changes, whatever they may be, are consequent.

But is there any organic change of state or operation in the brain connected with volition, simply considered? or is it an act of the soul or immaterial mind, without the cooperation of any part of the corporeal structure?

There is no reason to believe that volition has any local seat in the body, or that its exercise is accompanied by the cooperation of any organic change. There is no fact, of which I am aware, affording the slightest degree of evidence in favour of this supposition. Volition is an act of the mind, in the performance of which the nervous structure and brain have, perhaps, no share.

But the act of volition must be distinguished from its results. Volition, as we well know, even an act of the will to move the limbs, may take place in a paralytic; but it becomes abortive, unless the brain, the nerves, and muscles, are in a state to obey its mandates.*

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* I have repeatedly desired a patient perfectly paralytic on one side, to make a strong effort to move the paralysed limbs. I have witnessed that effort, or rather have stood by while it was made, without perceiving the least external result. Was not this act of volition (for it was such, though no muscular motion followed,) entirely in the mind? Those parts of the brain which are concerned in the voluntary exertion of the limbs, were in a state of disease which had abolished their function. What other cerebral act could be requisite, and where could such an act be performed, in the instance of this abortive volition? Are there

When the will acts upon the limbs to put them in motion, it is supposed to excite first some unknown operation in the brain, and this is believed to be followed by an action in the nerves of voluntary motion, which, according to Mr. Charles Bell's remarkable and important discoveries, are a particular set of nerves, and subsequently by actions of the voluntary muscles, to which these nerves are distributed.

This opinion was founded, and is chiefly supported upon pathological facts; it being known that diseases of the brain occasion palsies, or loss of the power of voluntary motion, and that similar effects arise from the dissection of nerves. The same opinion, as far as it relates to the nerves, is further rendered probable by the circumstance that contractions

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two cerebral operations required to set up the movement of the limbs, for we have observed that, owing to disease, one such operation was prevented? It is more probable that the act of the will, which took place in this instance, was solely in the mind, and that the only organic operation ever connected with it, was that which, in this case, did not follow; but, in a healthy state would, through the intervention of the brain and nerves, have set in action the muscles and limbs.

may be excited in muscles by stimuli, as that of electricity, applied to the extremity of a nerve; hence the energy communicated by the will, is compared to a stimulus, and thought to be one of a particular kind. This theory has the appearance of being tolerably well founded, and is probably true in its principal positions, though there are some difficulties in respect to that part of it which relates to the brain.*

In this case, we have not the least idea how the will can determine the motive impulse to one particular set of muscles or nerves, so as, for example, to move one limb.

The theory is still more hidden and obscure of those operations which, when the attention is directed to intellectual processes, the will can set up in the mind. These intellectual exertions of the will have their seat primarily in the Immaterial Mind itself, but they are succeeded, like the former class of voluntary exertions, by organic changes in the brain.

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* I refer particularly to the facts connected with cases of acephalous fœtus, in which infants born without brains have breathed. In a case of this description, recorded by Mr. Lawrence, the whole of the brain was wanting, and there was only a small knob, which terminated the spinal marrow. Yet the infant, as it has been remarked by Dr. Philip and Dr. Alison, had evinced some of the phenomena of voluntary action; it had exerted the muscles of respiration.

Among these voluntary or active exertions of the intellectual power, is judging, reasoning, or ratiocination, the faculty by which the mind judges of speculative truth, or, in moral questions, of right and wrong. In such exertions, the aid of memory, the recalling of ideas is necessary, as are perhaps many processes of the mind in which the brain cooperates, and which the will perhaps brings into action, by exerting its influence on the organic processes carried on in the brain.

The will has indeed no agency on the memory, but by availing itself of the association of ideas. Perhaps, indeed, the whole influence which the will can exert on the memory resolves itself into attention,* or the power which the mind possesses of directing its energy to one particular train of ideas, to the exclusion of others, and of thereby giving time and occasion for the reexcitement, in a state of freshness and vigour, of all the ideas and feelings which were originally associated with the object of its pursuit.*

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* "The connexion between attention and memory," says Mr. Stewart, "has been remarked by many authors. 'Nec dubium est,' says Quinctilian, speaking of memory, 'quin plurimum in hac parte valeat mentis intentio, et velut acies luminum à prospectu rerum quas intuetur non aversa.' The same observation has been made by Locke." *Philos. of the Mind*, vol. i. p. 106.

In following a train of reasoning, or ratiocination, the mind avails itself of this power of recollecting previously acquired ideas, partly, as it seems probable, through the aid of instrumental processes carried on in the brain, which it has to a certain extent under its command; but the exertion of the faculty of judgment itself, is a simple operation of the mind, performed with the consciousness of action and voluntary exertion. I am not acquainted with any fact which renders it probable that the act of the mind which is termed judgment, is connected with or dependant upon any operation of the brain. It may be thought that analogy would lead us to infer that the functions of the nervous fabric are instrumental to the exertion of this faculty, since we have reason to believe this to be the case with respect to other phenomena sometimes termed intellectual. But there is in reality no analogy between remembering and judging; between the operations of a faculty which only recals the impression produced by external objects, and of one which is conversant with relations. In the former instance the mind is passive; in the latter, as in the case of volition simply considered, it is in a state of active exertion; it acts with an energy beginning from itself.

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* This is, in fact, very nearly the account given by Aristotle, of the act and effort of recollection, or ἀναμνησις, in a passage of his work on Memory and Reminiscence, cited by Mr. Stewart, vol. i. p. 290. "When we recollect, we agitate some one of the former movements of the mind, until we have excited that with which the individual thought was habituated. Accordingly, in reflecting, we hunt in series from the present time to some other, according to the relations of resemblance, or contrariety or proximity. By this means recollection takes place."—*Arist. de Mem. et Reminiscentiâ.*

Imagination is another faculty which is brought into action by the will. Observations may be made respecting it, similar to those which have been applied to the faculty of reasoning. Imagination is very distinct from mere fancy or reverie; its province has been defined to be that of selecting qualities and circumstances from a variety of different objects, and of combining and disposing them to

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NOTE 1. PAGE 87.

THE curious discoveries lately made by M. Dutrochet, relative to the principle which he has termed Endosmose, appear to throw light upon many of the phenomena in vegetation, heretofore ascribed to vascular absorption, or to capillary attraction; but I am not aware that it is possible to derive from them an explanation of the facts brought forward by M. Theodore de Saussure, in his researches on the vegetation of plants in different fluids.

In these researches, two series of experiments tended to establish the same results.

1. Plants were placed separately in various solutions, containing the same quantities of different salts, and were kept in them till one half of the liquid had disappeared. The residues of the solutions were then examined, and they were found to contain very different quantities of the saline matters at first dissolved in them. But, what is equally important to the result, the quantity of saline matter absorbed, in most instances, bore a minute propor-

tion to the quantities dissolved in that portion of the water which had been absorbed. Hence it appears that plants refuse the absorption of saline matters dissolved in the fluids which surround their roots, or withdraw the water from them without admitting the salts, and that this is done with selection, some salts entering in larger proportions than others.

2. The second series of experiments consisted in dissolving various salts at once in the same fluids, and making plants vegetate in them. The result was analogous to that of the preceding series. Different proportions of the salts were absorbed.[*]

The theory of Endosmose does not, so far as it has hitherto been investigated by M. Dutrochet, explain fully the facts to which I have referred in pages 85—88; at least, I am not aware of any modification in the agency of this principle, into which they can be resolved. But the discovery is so new, that it is impossible to limit, as yet, its applications. If it should appear that the phenomena which indicate a selective absorption by the roots of plants, of certain portions from the fluids surrounding those roots, to the exclusion of others, can be explained on this principle, the discovery will furnish a striking example of the true and philosophical method of investigating physiological problems, and of the possibility of resolving what have been termed vital powers, into the agencies of inorganic matter, modified by the construction or disposition of parts in organized bodies.

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[*] An abstract of these experiments was given by Dr. Thomson, in his System of Chemistry, 1807, vol. v. p. 365, et seq.

NOTE 2. PAGE 100.

Remarks on the Theory of Secretion, which attributes that Phenomenon to Electrical Agency.

Being anxious to avoid lengthening too much that part of the preceding Essay which refers to Secretion, by introducing matters not immediately connected with the theory of a vital principle, I have not touched upon an hypothesis advanced a few years ago by an eminent writer on physiology, who ascribes the phenomena of the glandular function to the agency of the electric or galvanic fluid. It now remains for me to make a few remarks on that subject in a note. Although I am fully aware of the merits of the author of this hypothesis, and admire the ingenuity which he has displayed in correcting the erroneous conclusions of M. Le Gallois, and subsequently in defending the positions which he has himself advanced, I cannot consider the main principles of his theory as well established.

Dr. Wilson Philip has maintained that the principal agent in secretion is a fluid supposed to be transmitted by the nerves, in its nature identical with the galvanic or electric fluid. It is termed by him the nervous influence. He says, "It appears that the nervous influence is necessary to the function of secretion. It either bestows on the vessels the power of decomposing and recombining the elementary parts of the blood, or effects those changes by its direct operation on this fluid. From many facts stated or referred to in my inquiry, it appears that the vessels possess no powers but the muscular and elastic; and that the former, as well as the latter, is independent of the nervous system; nor is it possible to conceive any modification of these powers by which they could become chemical agents, and thus be enabled to separate and recombine the elementary parts of the blood. The first of the above positions may, therefore, be regarded as set aside; and the necessary inference seems to be, that in the function of secretion, the vessels only convey the fluids to be operated upon by the nervous influence."

From this passage it appears, as I think, that Dr. Philip sets altogether out of the question any operation of the vessels themselves on their contained fluids, as well as every species of mechanical action that might be imagined to result from the structure of secreting glands, and the vascular apparatus connected with them. Secretion is considered as simply a chemical operation. This theory might be classed with the theories of the chemical physiologists, but it is one of a peculiar kind. The sole agent is the nervous influence, or, what he considers as the same thing, the galvanic fluid, to which the nerve is the conductor. The material acted upon is the blood. The operation is a chemical decomposition and recomposition. The results are, the secreted fluids.

This explanation of the phenomena of secretion will scarcely bear the test of a close and accurate examination. If we begin by supposing the existence of the cause assigned, we shall find that there is one agent, namely, the galvanic fluid, operating on one material, which is the blood, and effecting its decomposition. How, then, we may ask, does it happen, that so many different substances are, in different examples of the same process, the results of this single operation? In other chemical decompositions, as when water is decompounded by the galvanic fluid, the result is the same, and uniform. But, in the instance supposed, the operation of the same chemical agents upon each other is followed by the formation of products of the most different descriptions; in one part of the vascular system, the blood is converted into bile; in another, by the operation of the same chemical agent, into milk; in another, into tears.

It cannot, then, be said that this hypothesis has any high claims, on the ground of its affording a successful explanation of phenomena. When we inquire, on the other hand, into the truth, and at any rate into the proofs which are alleged for the real existence of the cause assigned, we find nothing but doubts and conjectures.

On proceeding to the question, whether the assistance of the nerves, or of the function of nerves, whatever it may be in reality, is essential for the performance of secretion, no fact is more immediately striking than that secretion takes place under a variety of circumstances in which the cooperation of nerves is entirely precluded.

The most remarkable facts of this kind are furnished by those cases of congenital malconformation, in which the organization of the fœtus has been found to have been carried on to perfection, with either a total defect of the brain and nervous system, or with a deficiency of parts essential to their function. Nutrition has proceeded notwithstanding these defects, which implies that secretions have been continually carried on in the embryo, till the period of its maturity. In these instances, the brain has often been found wanting; in several of them, the brain, together with the spinal marrow; and, in one instance recorded by Dr. Clarke, in the Philosophical Transactions for 1793, there was "neither brain, spinal marrow, nor nerves."*

It will not be of any avail to object to these cases as deviations from the ordinary course of Nature, and as therefore having less weight in illustration of her laws. For, besides that such an objection would be without meaning, we shall find abundance of instances in which secretion is ordinarily and perpetually carried on, without the presence of nerves or brain. I allude to those species of animals which are destitute of nerves; in which nothing at all analogous to a nervous system has been discovered by the most accurate anatomical researches; and to plants, in the economy of which secretion is as certainly performed, and in which as great a variety of products result from that process, as in the animal kingdom.†

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* This argument, in refutation of Dr. Philip's hypothesis, is stated with its full force by Dr. Alison, in the tenth volume of the Quarterly Journal of the Royal Institution. See particularly pp. 279—281, where he has given a collection of the cases alluded to. See also Bostock's Elements of Physiology, vol. ii. p. 413.

† Dr. Bostock has well remarked, that the analogy of the vegetable kingdom may be fairly applied to the illustration of

These considerations render it evident that secretion is not essentially dependant on nervous influence, and they induce us to look for some other solution of the facts, from which such an inference has been thought to be deducible.

The principal of these facts are various experiments performed, not only by Dr. Philip himself, but, in many cases, by other physiologists, with the view of displaying the effects which a division of the par vagum will produce on the digestive function of the stomach. The results of these experiments are not uniform, but the general inference to be drawn from them appears to be, that the process of digestion is greatly impeded or entirely arrested, in consequence of the division of the nerves. The doctrine founded by Dr. Philip on these data is, perhaps, too general. He has inferred, not only that the secretion of the stomach depends upon the operations performed through the medium of the nerves which are distributed to it, but that secretion in general is the result of the nervous agency.

It must, indeed, be confessed that there are many well-known facts, which, to a certain degree, afford countenance to this supposition, and at least indicate that the secretions are liable to be affected by various states of the nervous system, and even of the mind.

But the conclusion drawn by Dr. Philip does not

this question; for although we may regard its powers and functions as essentially different from those of animals, yet, on this particular point, they admit of comparison.—*Elements of Physiology*, vol. ii. p. 415.

appear to be established, even so far as the particular secretion of the gastric fluid is concerned. When the stomach is paralysed by the division of the par vagum, digestion does appear to have been arrested, or at least greatly diminished. But this may depend, as it has been suggested by MM. Breschet and Edwards, not upon the absence of the gastric fluid, but upon a complete loss of muscular energy, amounting to paralysis, in the fibrous structure of the stomach, induced, as paralysis is in other instances occasioned, by a division of nerves.* In consequence of the total loss of muscular power in the stomach, the functions of that organ are probably impeded in several ways; the alimentary substance remains in a mass, and ceases to be acted upon by that perpetual movement of the muscular fibres which brings it into contact with the coats of the stomach, and perhaps contributes in other ways to its digestion. The loss of these cooperating influences may contribute greatly to destroy or impede the digestive process, without any interruption in the secretion of the gastric fluid.

It seems to be a confirmation of this opinion, that in many instances in which, after the division of the nerves, the digestive power of the stomach has been impaired, a fluid has nevertheless been found to have been secreted, not less in quantity than under other circumstances. The opinion that it is altered in quality, has been gratuitously assumed.

A fact, the evidence of which is directly in opposition to the inferences drawn by Dr. Philip, on the cessation of secretion by the division of nerves, has been developed in the course of his own ingenious and well-described experiments. It appears from the account of these experiments, that the destruction of the lower half of the spinal marrow had no effect in preventing or lessening the secretion of the kidneys.*

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* See Bostock's Elements of Physiology, vol. ii. p. 408.

That injuries, however sustained by the nervous system, or by particular parts of it, and that powerful affections of the nervous system, however induced, are accompanied by considerable changes in the state of the secretions, is a fact which admits of no dispute. We know that conditions of the mind influence the secretions, the appetite, and digestion; that morbid nervous affections influence the secretions in a remarkable manner; as, for example, in the effects of hysteria on the kidneys. But perhaps these facts admit of an explanation of a different kind from that which the advocates for the direct influence of the nerves on secretion are disposed to maintain. A question may be moved how far these changes are brought about by the action of the nerves on the glandular fabric, and how far through the medium of the sanguiferous system. It is well known that sudden emotions, passions, desires, various states of the mind, give rise to particular determinations of blood, or are accompanied by a temporary increase in the circulation of blood through the small vessels in different parts of the body. Every person has witnessed visible proofs of this fact, in the suffusion occasioned by shame or by anger, which give rise to a sudden determination to the superficial vessels of the face. Medical practitioners are likewise aware that different morbid states of the nervous system are connected with similar modifications in the condition of the circulating vessels. It is, then, a general and well-established fact in the animal economy, that the state of the circulation through the vessels of particular parts, is subject to influences arising from affections of the nervous system. Hence it is probable that, when the secretions are diminished or increased in consequence of changes in the nervous system, this result is produced through the medium of the circulation of blood. A local plethora is induced in the vascular apparatus of secreting surfaces, or of glands, in connexion with sensations, or mental feelings, or with nervous sympathies, and this local plethora is the cause of increased secretion. When an opposite state arises in the vascular system, the secretion is proportionally diminished or suppressed. If this be really the connexion of morbid changes in such cases, the apparent influence of the nervous system on the state of the secreted fluids is explained, without supposing that the nerves are in any other way concerned, as *agents or as immediate instruments*, in the process of separation; a notion which, as we have seen, there are so many facts, derived from a comprehensive survey of the animal economy, to contradict.

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* Observations on the Theory which ascribes Secretion to the Nerves, by Dr. Alison.—*Quart. Journ.* vol. ix. p. 120.

NOTE 3. PAGE 113.

Survey of certain Difficulties attending the Theory of Animal Heat, which refers the Phenomena to the process of Respiration.

The only important objection which has been urged against the theory which connects the production of animal heat with the function of respiration, is derived from the well-known experiments of Mr. Brodie.

In these experiments, which were conducted with the greatest skill, and the results of which were striking and unexpected, it was proved, that when an animal has been decapitated, or when the function of the brain has been totally destroyed by the application of narcotic poisons, and the action of the voluntary muscles, which is necessary for natural respiration, has been thereby arrested, that function is so far imitated by the artificial inflation of the lungs, as to change the colour of venous blood, as in natural respiration, and at the same time to consume the oxygen of the air inflated, and convert it into carbonic acid. This change, like that which is carried on naturally, is analogous to combustion, and it would be therefore expected that the evolution of a corresponding portion of caloric would be the result. It was found, however, that respiration thus artificially maintained, instead of producing an increase of temperature, had, on the contrary, a refrigerating effect, when the air inflated was colder than the blood; the bodies of animals on which this process was carried on, were cooled in a shorter time than those that were left alone. The conclusion drawn from this fact was, that the chemical change produced by respiration in the state of air inspired, is not the source of animal heat.

This objection is evidently entitled to considerable weight. It would be sufficient, until fully explained, to induce the rejection of a mere hypothesis. But the chemical theory of animal heat is a philosophical doctrine, built upon facts well established, and assuming no causes but such as have been satisfactorily shown to exist. It is, therefore, not to be overthrown by difficulties which may be adduced, until it shall have been demonstrated that these difficulties admit of no explanation that is consistent with the theory. On reflecting upon this subject, I have long ago come to the conclusion, that there must have been some essential circumstance in which the respiratory process artificially maintained, differed from natural respiration. The most probable circumstance of difference in these two operations must consist in the quantities of air inflated or received into the lungs. If the quantity of cool air forced into the lungs artificially be greater than is required for the ordinary chemical process which is carried on in natural respiration, it is evident that the result of this excess must be to refrigerate the lungs and the entire body. It was highly satisfactory to me, to find this suspicion confirmed by the experiments instituted by Le Gallois and Dr. Philip, and to observe that the opinion which these experiments tend to establish, has been adopted by so clear-sighted and judicious a writer as Dr. Bostock. It is observed by this eminent physiologist, that "in the natural or entire state of an animal, the respiration is regulated partly by the influence of volition, and partly by instinct, the quantity of air respired being just sufficient to answer the demands of the system; but in the experiment which has been related, the air is forcibly sent into the pulmonary vesicles, without any co-operation from the animal, and of course independently of the correspondence between the different functions which are connected with the action of the lungs. Now, as we have observed, respiration may be considered as a compound process, one essential part of which is to abstract heat from the body; the question therefore to determine is, whether the heating or cooling effect of respiration will preponderate under the circumstances in which the animal was placed in these experiments."—" Perhaps, therefore, in the case in question, where a quantity of cold air is forcibly propelled into the lungs, and a portion of the heat necessarily rendered latent, by the conversion of venous into arterial blood, and where we may also presume that the air which is discharged from the lungs would carry off a quantity of aqueous vapour,"—" the result which we ought to expect would be, the cooling of the blood, as Mr. Brodie found it in his experiments." *

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* Dr. Philip's experiments tend powerfully to support this conclusion. In them it was proved, that when a less quantity of air is used in artificial respiration, the cooling of the body is

It must be allowed that these are facts which tend to show that the evolution of animal heat is, under particular circumstances, liable to be affected by changes in the state of the nervous system, and even in that of the mind. But all these phenomena admit, if I am not greatly in error, of a different explanation.

Every body must have observed, that some passions or emotions are attended with a sense of coldness, and others with that of heat. We might here appeal to the expressions handed down from a period long antecedent to all physical theories on these subjects. The paleness and chilliness of fear is often noticed.

> "Gelidus per ima cucurrit,
> Ossa tremor."

and

> *δείματα*
> *Αμφήκει κέντρῳ*
> *Ψύχειν ψυχὰν ἐμάν·* *

As mental emotions, without observably affecting the function of the lungs, produce an alteration in

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sensibly retarded, instead of being accelerated by the inflation, so as directly to obviate Mr. Brodie's objections, and to exemplify the power of the lungs in generating heat. Similar inferences resulted from the experiments of Le Gallois; and it seems to be established by them, in conjunction with those of Dr. Philip, that artificial respiration, though less perfect than natural respiration, is actually a source of heat.

* See Prometh. Vinct. v. 717. The physical effects of the emotions of fear are described in a more striking manner,

the temperature of the body, it may hence be suspected that this temperature depends, in some degree at least, upon other conditions than the states of respiration.

These facts appear, at the first view, to be in opposition to the theory which ascribes animal heat to the changes going on in the lungs; yet, if I am not mistaken, they may be explained in such a manner, as rather to coincide with that theory, and even to confirm it and extend its application.

According to the theory of Dr. Black, whether considered under the modifications suggested by Crawford, or in its original form, the circulation of blood is the medium by which increase of temperature is communicated, from the centre of its evolution in the lungs, to the extremities, and to every part of the body. It is by the blood circulating through the extreme vessels, that the different surfaces are warmed; and this, whether sensible heat is there evolved from its latent state, or simply conveyed by means of the already heated fluid. Whatever circumstances affect the circulation through the extreme vessels, ought therefore to exert a cor-

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though somewhat extravagantly, in another passage of the same poem.

ἐλελελελελεῦ;
ὑπό μ' αὖ σφάκελος καὶ φρενοπληγεῖς
μανίαι θάλπουσ', οἴστρου δ' ἄρδις
χρίει μ' ἄπυρος,
κραδία δὲ φόβῳ φρένα λακτίζει·
τροχοδινεῖται δ' ὄμμαθ' ἑλίγδην,
ἔξω δὲ δρόμου φέρομαι, λύσσης
πνεύματι μάργῳ, γλώσσης ἀκρατής· v. 900.

responding influence on the temperature of parts. Now, the passions display a most conspicuous effect on the circulation through the extreme vessels. Nothing can be more manifest than the sudden increase of fulness in the subcutaneous vessels, which takes place in a violent fit of anger, or in the blush of shame. In the paleness which accompanies fear and anxiety, the contrary phenomenon, a contracted state of the superficial vessels, with a retirement of blood into the interior parts, is equally evident. It is to these effects on the circulation, produced no doubt through the medium of the nervous system, that we are to ascribe the modifications of animal temperature, to which passions or mental emotions give occasion. They, therefore, oppose no obstacle to the chemical theory of animal heat.

I am persuaded that other facts which display an influence over animal temperature lodged in the nervous system, and those instances in which a diminution of heat follows injuries of the nerves, will be found to admit of a similar explanation; that the effects follow from changes taking place, in the first instance, in the circulation through the extreme vessels in different parts of the body. That such changes in the state, in the action, or at least in the capacity and fulness of these vessels, and therefore in the quantities of blood admitted into them, and circulating through them, are produced by affections of the nervous system, every physiologist and medical practitioner is most familiarly aware; but that there is any power seated in the nervous system, which immediately, and without the intervention of the organs of circulation, affects the temperature of the body, is a supposition highly improbable, and supported by no proof.

NOTE 4. PREFACE.

Survey of other Opinions which have been maintained respecting the principal phenomena of Life.

The writers I have chiefly alluded to in the Preface, are MM. Bichât and Cuvier, in France, and Mr. Allen and the late Dr. Gordon, in this country; but, before I bring this work to a close, I think it advisable to add a few remarks on some other speculations connected with the theory of life, which differ from the celebrated Hunterian doctrine.

I must first observe, that, in giving this designation to the theory which I have surveyed in the preceding pages, I do not mean to assume that every part of it originated with the great physiologist whose name it bears. But since the leading principles are either expressed or implied in his writings, which have been extended and followed out by his successors, I have considered it allowable to survey the whole system in one point of view, without attempting critically to appropriate particular parts of it.

Before the time of Mr. Hunter, a very different mode of theorizing, or of contemplating the phenomena of life, prevailed among the physiologists of this country. The celebrated Dr. Mead maintained a theory which may be considered as a modification of the mechanical doctrine. He compared the living body to a machine endowed with the property of perpetual motion. "It is God alone," he says, "who can complete such a machine, and was pleased that our body should be a fabric of that sort, by disposing all its parts in such a manner, that they should form a kind of circle, *in which, at the same time that they perform their respective functions, they should constantly and mutually repair each other.*"

It must be confessed that the mechanical physiologists were often too hasty in referring to the principles of mechanism, when they attempted to explain the phenomena of the living body, and that they were not sufficiently observant of the very peculiar circumstances under which the agencies of life are carried on; but their successors have gone to the opposite extreme—for, having once invented the terms, vital action, laws of vitality, living powers, &c. they deem it quite sufficient for the explanation of difficult phenomena to refer to them, as if to occult powers for which no further elucidation is to be sought, or can possibly be attained. Some French physiologists have of late pursued a different course, and the care with which they have applied to the study of the ultimate organization of plants and animal bodies, with the view of explaining facts often considered as beyond the scope of research, has not been wholly unrewarded.

There are two theoretical views of some of the leading phenomena of life, which have of late attracted a considerable share of attention among physiologists, and on which, partly for that reason, it will be advisable to make some remarks at the conclusion of this Essay. The first is, the doctrine of the *Bildungstrieb*, or Nisus Formativus, which originated with the venerable Blumenbach, and which has been adopted recently, together with the terms connected with it, by some of the most distinguished naturalists in France.

1. *Of the Doctrine of a Bildungstrieb, or Nisus Formativus.*

The theory of the Nisus Formativus is a well-known speculation of Professor Blumenbach's. It was first advanced by him, nearly half a century ago, in a paper which appeared in the Magazin der Wissenschaften und Literatur, published at Göttingen.* In many later works, the author has reverted to the principles which he enounced in that Essay, as he has found occasion to touch upon the subject; but he has nowhere, as I believe, so fully expressed himself as in the paper alluded to.

It has been thought by some, that there is no small degree of obscurity in Blumenbach's ideas on this subject; and partly on this account, and as the Essay in the Göttingen Magazine, which contains some ingenious and original observations, is accessible to few persons in this country, I have determined to take this opportunity of presenting my readers with a translation, or rather an abstract of it, omitting such parts as seem to me but little connected with the object of the present work.

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* Prof. Blumenbach, über den Bildungstrieb (Nisus Forma-
seinem einfluss auf die generation und reproduction.

The author was first led to speculate upon this subject, by observing the phenomena displayed in a particular kind of green polypus, which he found in a mill-stream, and which was distinguished from the ordinary green species by a long spindle-shaped body, and short, stiff arms. The peculiar constitution of this polypus was so favourable to the common experiments on its reproductive property, that the process by which its form is restored, seemed to go on visibly after mutilation. The animal when cut seemed to shoot out in a very short space of time new arms and tails, but it was observable that, as this reproduction of its members went on, in a like proportion did the truncated body become shorter and thinner, lessening by degrees its original mass of substance.

Blumenbach had soon occasion to compare the phenomena above described with appearances such as take place not unfrequently in the healing of deep wounds with loss of substance, in which the sound flesh in the adjacent parts is observed to sink or subside, undergoing an actual diminution of its solid mass, in such a way as to restore an equality of surface,* and thus displaying, *mutatis mutandis*, similar changes to those which were seen in the polypus.

A comparison of these appearances gave rise to a train of reflections, by which the author was led to the following results.

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* He refers to "Observations par MM. Faber et Louis, des Plages avec perte de substance," in the Mémoires de l'Académie de Chirurgie, tom. iv. pp. 74 and 106.

"That in all creatures endowed with life, from man down to the maggot, and from the cedar to common mould or mucor, there is ever inherent a particular effort or tendency which, while life continues, is active and operative; in the first instance to attain the definite form of the species, then to preserve it entire, and, when it is infringed upon, so far as this is possible, to restore it.

"This effort or tendency, or impulse, as any one may prefer to term it, which must neither be confounded with the universal properties of bodies, when these are considered in a general point of view, nor with the peculiar qualities of organized bodies in particular, is among the first causes of all the phenomena of generation, nutrition, and reproduction. In order to prevent misapprehension, and to distinguish this from all the other powers of Nature, I purpose to appropriate to it the designation of 'Bildungstrieb, or Nisus Formativus.'

"As some late writers," continues Blumenbach, "have been sharp-sighted enough to discover the circulation of the blood in the Preacher of Solomon, and muscular irritability in Homer, so it will not be a matter of wonder, if the Nisus Formativus should be traced in all the numerous works on generation, which have been written during the last two thousand years. Yet I must, in this case at least, warn such ingenious persons, that they are not to confound the *Bildungstrieb* with the Vis Plastica, or with the Vis Essentialis,* or with any of the chemical

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[*] Yet the office assigned to the Vis Plastica and to the Vis Essentialis, by the authors who are cited by Blumenbach in this

or merely mechanical powers which have been called in to aid in the processes chiefly under consideration, and that we are not concerned at present about the name, or about the mere proof of the existence of this principle, but about its importance, and the great part which it universally performs in giving life to the whole organized world.

"A truth," says the author, "which must never be lost sight of in these inquiries, and the neglect of which may often already have impeded their successful prosecution, is this, that generation, nutrition, and reproduction, are fundamentally mere modifications of one and the same energy, which in the first instance constructs, in another maintains, and in a third, repairs; in other words, nutrition is an uni-

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place, are analogous to that of the *Bildungstrieb*, and their expressions are remarkable as coming near to the vital principle of some other physiologists. In the first place, the vis plastica is so defined by Francis Bonamico, the Aristotelian, (De Formatione Fœtus, p. 528.) It is a *Spiritus* contained in and operating upon the original material, or rudiments of the fœtus. "Dum vero ea fabricat, appellatur facultas διαπλαστικη seu δημιουργικη. Sed ubi extructa fuerint instrumenta, ut iis uti queat, quæ prius erat vis formatrix, illis utens degenerat in *Animam*."

The celebrated Wolff, the inventor of the vis essentialis, thus defines it. "It is that power by which, in vegetable bodies, all those processes are carried on, in virtue of which we ascribe life to them; on this ground I have termed it the vis essentialis of such bodies; because a plant would cease to be a plant, if this power were taken away. In animals it has its place, as well as in vegetables, and all those properties which animals have in common with plants, depend entirely on this power or principle." Casp. Friedr. Wolff, Theorie von der Generation, S. 160.

versal but imperceptibly continued reproduction, and the latter, a repeated but only partial generation. A ray of light thrown upon either one of these three processes, would undoubtedly contribute to illustrate both the others. In essential respects, they all coincide; the *Bildungstrieb* has an equally important operation in all; it is chiefly the occasion which sets this property in action, as well as the particular mode in which its energy is displayed, that is different under varying circumstances. Thus, in order that the first of the three modes above-mentioned may subsist, definite circumstances are requisite, which are of such sort, that we are obliged to imagine the existence of parents, and a series of ancestors up to the very beginning of creation, as necessary conditions for the production of any one individual of any kind.

"There was, indeed, a time when this mode of successive propagation was not thought so absolutely essential; when fleas were not supposed necessarily to have originated from other fleas, crabs from other crabs, and mice from mice, but when fleas were imagined to be bred in wet saw-dust, crabs in stale meat, and mice to spring out of mud, or filth and dirt of any description. This equivocal generation was heretofore a most convenient refuge of ignorance, and a fountain and support of every imaginable folly and superstition. It is now long since this false system was demolished, and from that time it has scarcely ever been mentioned, except as we mention flying witches and the diviner's rod, for a memorial of former ignorance, and of the peaceable triumphs of our enlightened times.

"In the mean while, it would almost appear as if the adventurous imagination of the scholastics had induced the more enlightened philosophers of late ages, to proceed too far in the opposite direction; and, as if a period may yet come, when some exceptions, within very narrow limits, may be allowed to exist to the general doctrine of propagation.

"Certain it is, that there are yet phenomena in the history of organized bodies, in the explanation of which this strictly so termed propagation entirely deserts us, and in which we can with far more probability recur to a certain species of '*Generatio æquivoca*,' and must allow that, occasionally at least, juices of various kinds, by a particular species of fermentation or corruption, take on them a *Bildungstrieb*, and spring up into a diversity of simple or perhaps imperfect attempts at vegetation.

"To adduce only one such example of vegetation,—and that not a mere mould or incrustation, in which the opponents of the *generatio æquivoca* might come in with their ever invisible aerial seeds and other subtile inventions, but a true plant, in consistence and colour resembling other and more perfect vegetables, and yet neither produced by its like, nor itself adapted to propagation,—I would mention the growths which are occasioned on plants of every description, by the simple puncture of the gall-fly, and particularly the gall or bedeguar, which is found on the wild rose-trees. These are not accidental excrescences or monstrosities, but regular and definite vegetable forms, which are destined to a particular object; but which, on the other hand, have as little resemblance to the rose-tree on which they grow, as the mistletoe and other parasites have to the plants on which they are respectively found. I do not perceive how it is possible for the defenders of the doctrine of pre-existing germs, to make anything of these growths, of which it can scarcely be pretended that the rudiments had been preserved from the beginning of the creation, and transmitted through successive generations of plants in the undeveloped state.

"On the other hand, there is no improbability in the supposition that in the exuberant juices which are thrown out after the puncture of the insect, by means of the wound and the eggs deposited in it, and by other changes induced, a *Nisus Formativus* may be excited, which forms these juices into the gall, as in other instances, by the usual causes of fertilization, the elements of the plant receive a similar impulse to the formation of a new vegetable body, organized according to the regular laws of parentage.

"But it is under the dominion of these far more general laws, that the influence and energy of the *Bildungstrieb* are most indisputably displayed. All the phenomena of this process,—the circumstance, for example, that the first appearance of developement takes place, not immediately after the fertilization, but on the elapse of a certain interval; and that this developement having once commenced, the growth of the newly organized fruit proceeds afterwards with so much the more rapidity;—these facts admit of an easy explanation on the hypothesis of the Nisus Formativus, and so likewise does every suggestion which has occurred to me, as opposing some apparent difficulty to the same doctrine.

"Even the production of monstrosities not only detracts nothing from the definite nature of this principle, since there is no reason why it, like other physical powers, should not be occasionally disturbed in its operation by accidental circumstances, and assume a deviating course;—but the surprising, though perhaps as yet little observed analogy, which subsists among these productions, gives to the doctrine itself a new and very considerable support.

"Since the deflections from a right line may be infinitely various, it would appear, at the first view, as if also in monstrous productions, those deviations from the uniformity of Nature in the structure of organized bodies, there might be discovered a variety equally without limit, and a multiplicity quite accidental. But, on a nearer inquiry, it rather appears that a wonderful analogy prevails in most of these examples, and that consequently also the causes, which in such instances give to the Bildungstrieb a false direction, and thereby occasion the production of monstrosities, are yet connected with very determinate laws. Those who have ever had opportunities of comparing together a considerable number of such examples of malformation, or who have only studied with attention the hitherto sterile compilations on this subject, cannot have failed to observe the striking resemblance which, even in minute circumstances, is constantly to be traced between monstrosities of each particular kind, and which is so exact, that the examples of each sort would seem to have been cast in the same mould. But it is a still more striking fact, that one species of monstrosity is found most frequently in the human species, another in lambs, a third almost exclusively in swine, which generally, among all animals in the creation, are most subjected to such deviations in structure. On the whole, domestic animals are far more subject to the production of monstrous births than wild ones, and the warm-blooded than cold-blooded. Among these last, though malformations of particular parts, as of the head, are occasionally met with, the appearance of double bodies or limbs is, as far as my information extends, totally unknown.

" The production of monsters displays a very forced and unnatural deviation of the Nisus Formativus, and, accordingly, one which never, or in examples of the most rare occurrence, is continued by propagation. It is far otherwise in the case of varieties in the species of organized beings, in which the altered direction given to the Bildungstrieb is effected in a manner more gentle, less violent, but so much the more deeply rooted, and calculated to affect the progeny.

" To the class of causes which are capable of influencing the Bildungstrieb in this hereditary manner, belongs in an especial degree the commixture of dissimilar breeds; those which take place between different species producing proper mules, and those between merely different varieties, as between negresses and white men, mulattoes, or blendings. In a manner somewhat analogous it would appear that climate, temperature, and other external causes, influence this tendency, so as to give rise to national forms and family peculiarities of countenance.

"But the most remarkable among all the deviations of form, are certainly those instances which are induced at first by art, in consequence of particular habits or national customs, but become by degrees more durable, and at length are, as it were, imprinted by a second nature, and are found even to be hereditary."

What I have hitherto said in proof of the evident influence of the Bildungstrieb, on the phenomena and process of propagation, obtains its full weight only when it is compared with the phenomena of reproduction, which, as I have before remarked, is a partial and repeated generation, and this brings me back again to that point which I had reached at the beginning of this digression.

I have often repeated the experiments before alluded to with polypi, both of the green and of other species, and have always met with a similar result; but it was ever most perceptible in the green species, that the zoophyte when mutilated became smaller, nearly in proportion to the celerity with which its arms or hinder parts were reproduced. It was remarkable what haste Nature seemed to make to replace the mutilated animal in its definite form and structure, and that as sufficient substance could not be furnished in so short a space of time, by means of nutrition—for which a mutilated polype is not so capable as a complete one—the trunk of the zoophyte was obliged to surrender, as it were, a part of its component material, which was, through the agency of the internal Bildungstrieb, cast into the figure of the lost limbs, and thus the shape of the body, which had been destroyed by mutilation, again restored. It is easy to explain why this restoration is carried on most quickly in polypi, more slowly in earth-worms, sea-anemonies, and sea-stars, and yet in a more gradual manner in crabs and water salamanders. To understand this difference, we need only refer to the greater simplicity of structure in the former, than in the last-mentioned animals.

Organized bodies of all descriptions have their Nisus Formativus, and consequently also a power of reproduction; and the great difference which appears to exist in this particular between the cold-blooded and the warm-blooded, becomes, on a more accurate examination, much less important. It certainly appears, as we have observed, when alluding to the production of monsters, that the Bildungstrieb works by more infallible rules, and with greater force and vivacity, in creatures with cold, than in those with warm blood; yet it is probable that the power of reproduction has been underrated in the last, few experiments having been as yet instituted to ascertain its power and the extent of its operation; and I do not abandon the hope that when, by repeated attempts, all the opposing circumstances shall have been ascertained, which impede in its office the reproductive process, the human mind may yet discover some means, at least in a degree, of overcoming them. Reproduction is the great object of the art of surgery, and we thus perceive how extensive a prospect this suggestion seems to hold out for the ultimate improvement of that art, and therefore for the alleviation of human misery; and how, by such an application of natural history, the most delightful and instructive of all human sciences may likewise assume the character of the most useful and beneficial.

The preceding observations of Professor Blumenbach are highly interesting, as serving, when surveyed in connexion, to illustrate those tendencies of the animal economy, which contribute to support the existence and definite capabilities of organized bodies. The term Nisus Formativus, adopted by the author, is unexceptionable, if understood only to designate and generalize a series of facts connected together by the circumstances that they all display agencies contributing to the same end; but it must not be looked upon as affording any explanation of the efficient powers by which the phenomena observed are brought about. Neither can the whole series of phenomena be philosophically resolved into a simple law of Nature; a more accurate insight into the functions of organized bodies would no doubt throw further light on the immediate changes by which the results are effected. But on this subject I have nothing further to add in this place, as the remarks made in Section XIV. of the preceding

Essay, with reference to the plastic operations of Nature and the developement of seeds and ova, apply equally to the doctrine of the Bildungstrieb.

The doctrine of Blumenbach has of late been warmly espoused by M. Geoffroi St.-Hilaire, in two essays which have appeared, not long since, in the Mems. du Muséum d'Histoire Naturelle.*

This celebrated naturalist has adopted the term Nisus Formativus, and the general idea of its nature, but has assigned somewhat narrower limits to its operation. He says, "Par cette expression on comprend les efforts ou la tendance de l'organization, pour se développer d'une seule et même manière, pour donner les résultats que nous disons ceux de la règle, pour faire réapparoitre des produits, qui répètent exactement les formes des anciennes races."†

In another passage, he terms it "Le principe qui préside à l'ordre successif des générations, au rétour obligé des mêmes formes, et par conséquent à la réapparition des même espèces, c'est à dire cette tendance à des developpemens réguliers, que je comprends, et que j'exprime par le môt de Nisus Formativus."*

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* The first is entitled, "Rapport fait à l'Académie Royale des Sciences, sur un Mémoire de M. Roulin, ayant pour titre. Sur quelques changemens observés dans les animaux domestiques transportés de l'ancien monde dans le nouveau continent. Par MM. Geoffroi Saint-Hilaire et Serres." The second is, "Mémoire où l'on se propose de réchercher dans quels rapports de structure organique et de parenté sont entre eux les animaux des ages historiques, et vivant actuellement, et les espèces antediluviennes et perdues. Par M. Geoffroi Saint-Hilaire." (Mem. du Muséum, 9^c^ année.)

† Ibid. p. 203.

To this principle of permanency in organization is opposed the whole assemblage of external agencies, which tend to deflect it from its course, and occasion variations of structure; and from the joint operation of the two causes, or from their *antagonism*, is said to result the actual condition of organized beings. The last series of agencies are termed—"forces de résistance." "C'est surtout chez les êtres vivans que cet antagonisme se manifeste. Aux forces qui tendent à les développer, sont opposés, commes conditions de résistance, des effets d'affinité, et généralement l'action des agens physiques qui pèsent sur eux de toute leur force."†

M. Geoffroi St.-Hilaire coincides with Lamarck in supposing the influence of external agencies on organization to be more extensive than it is commonly held to be by naturalists. It is capable, or has formerly been so, of transmuting one species of animals, and even one genus, into another, so that the present tribes are descended from the antediluvian races which M. Cuvier, and all those who adhere to his school, regard as entirely distinct creations. Allow the influence of external agents to have been at one time far more conspicuous than it is in the present state of the world, then he says, "Vous apercevez un réelle parenté entre les espèces perdues, et les animaux de l'ordre actuel. Effectivement, tous ne sont ils pas entrés sans difficulté dans les cadres des grandes classifications? tous,

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[*] Ibid. p. 214. [†] Ibid. p. 203.

commé ètant formes d'organes analogues, ne vous semblent ils pas les modifications d'un même être, de cet être abstrait, on type commun, qu'il est toujours possible de désigner par un même nom, et que présentement vous appellez animal vértebré?"* The author even expresses approbation of the hypothesis of M. de Lamarck, for which he apologizes by citing a passage from Pascal. "Les êtres animés n'êtoient-ils, dans leur principe, que des individus informes et ambigus, dont les circonstances permanentes au milieu desquelles ils vivoient, ont décidé originairement la constitution?"†

M. Geoffroi St.-Hilaire has not yet explicitly unfolded his own views on this subject, but if he adopted, in their fullest extent, the ideas to which these expressions point, his system would appear to be very nearly that which Dr. Darwin has adorned in so splendid and poetical a garb, in his "Temple of Nature." The Nisus Formativus will then fill nearly the office of Darwin's *appetency*. Such speculations only serve to show us to what extravagancies ingenious men may be led, if they give a loose rein to their imaginations. When stripped of the abstract phraseology which imposes upon us, what can be more absurd than the notion which this scheme presents to us?—that men and toads descended from the same original parents, and became different through a constant appetency to become so, or through the agency of the different media which surrounded them.

M. Geoffroi St.-Hilaire has entered somewhat

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[*] Ibid. p. 211.

[†] Ibid. p. 217.

fully into the arguments in defence of the Nisus Formativus, and in opposition to the theory of pre-existing germs. He dwells on the same considerations which were adverted to by Blumenbach, in the paper of which I have given an abstract.* These are, in the first place, the phenomena of variety, or deviation in species of animals, a subject on which light has been thrown by the memoir of M. Roulin;† and, secondly, the appearances connected with monstrosity, on which he has made an extensive series of experiments, by means of artificial incubation. "J'ai procédé," he says, "sur un grand nombre d'œufs de poule. Ayant opéré sur les masses, j'ai toujours obtenu le produit cherché. Là donc j'ai fait des monstres à volonté"—"de telles et telles qualités. Changeant les conditions des modificateurs externes, j'entrainai les développemens dans une voie inaccoutumée."

"Cependant le but sécret de mes récherches, que je ne crains plus d'avouer dans ce temps de meilleurs jours, fut l'examen d'un principe qui dominoit les plus hautes questions de l'organization animale."

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* It seems remarkable, that in adopting a train of reasons so nearly analogous to that of the venerable professor of Göttingen, the author should have made no reference to his name. Blumenbach's essay on the Bildungstrieb had probably escaped the observation of M. Geoffroi St.-Hilaire.

† The facts related by M. Roulin respecting the effect of a change of climate, and the return to a wild state of domesticated races which had been transported to South America, are highly important. Many parallel remarks may be seen in Blumenbach's Beyträge zur Naturgeschichte, and in Don Felix de Azzara's Account of Paraguay.

In this country we can scarcely imagine a persecution which should render it dangerous for a naturalist to avow any object of experiments in hatching pullets' eggs, but all must rejoice at the overthrow of so preposterous and almost ridiculous a despotism.

The papers already published on this subject by M. G. St.-Hilaire, are only the first of a series of memoirs. His views are not yet developed, and when we shall be enabled fully to understand them, it is probable that what now seems to border on the extravagant, which however rather belongs to the system of M. de Lamarck than his own, will bear a very different aspect.

2. *On the Theory of Living Atoms.*

A variety of observations have been made within a few years, with the aid of the microscope, by some distinguished physiologists in France, on the intimate structure of animal and vegetable bodies. The writers I refer to, are Messrs. Dutrochet, Dumas, and Prévost, but particularly Dr. Milne Edwards. Many of the phenomena described by them, had been previously observed by other microscopical investigators, but they have now been brought forward in a more systematic and connected manner, as the results of more elaborate research. The reason which has induced me to refer to them in the present instance, is the circumstance that by some persons these observations have been thought calculated to establish new and very remarkable opinions as to the mode of subsistence of living bodies.

According to Dr. Edwards, the intimate structure of all the component parts of animal bodies is, in the essential circumstances, nearly similar. Not only the cellular tissue or membrane, which composes most of the common structures of the body, as the membranes, parenchymatous, and vascular parts, but likewise the muscular fibres, nerves, and brain, appeared to him to consist (when examined by powerful magnifying glasses,) of rows or series of minute globules. Those of which the cellular texture is composed, are all of the same size, that is, the $\frac{1}{300}$ part of a millimetre, or somewhat more than the $\frac{8}{1000}$ part of an inch in diameter; they are disposed in series, which cross and intersect each other in all directions, and are connected together by a sort of irregular tissue or net-work. The muscular parts consist likewise of globules, which are of the same dimension, but disposed in lines of parallel direction. These are also of the same size in all animals. The component globules of the cerebral substance are similar, but their texture is intermediate between that of the cellular and muscular substance, and there is a fatty matter interposed between the rows of these globules.

The researches of Dr. Edwards had reference to animal bodies.* Those of M. Dutrochet comprehended also the intimate structure of plants.* MM. Dumas and Prévost directed their attention to the component particles of fluids, and particularly to the globules of the blood.

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* Récherches Microscopiques sur la Structure intime des Tissus organiques des Animaux. Par M. H. M. Edwards, M.D. *Annales des Sciences Naturelles, Dec.* 1826.

The most important circumstances connected with these researches, are the phenomena observed on the disintegration or decomposition both of animal and vegetable matter. When portions either of animal or vegetable matter were for a short time macerated in water, and a drop of the water examined by a microscope, numerous vesicles of various sizes were repeatedly seen moving about in all directions. It was concluded that these were a portion of the constituent molecules of the original compound body, which had now become separated, and their movement was looked upon as an unequivocal proof of spontaneous action and of individual life. Similar phenomena were observed in surveying the spherical molecules of uniform size, which are seen in the pollen of phanerogamous plants, in the antheræ of mosses, and around the stamina of equisetum. The nature of these particles was compared to that of infusory animalcules. The analogy was imagined to subsist, not only in the visible structure or appearance of their several bodies, but even in their mode of existence and essential properties. It has been supposed that the elementary molecules of these several classes may be identified, and that they are capable of being converted mutually into each other; vegetable particles into animalcules, and animalcules into vegetable particles; both resulting as independant living monads, and requiring no revivifying process, from the decomposition, or, rather, mechanical dissolution of larger and compounded bodies.

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* Récherches Anatomiques et Physiologiques sur la Structure intime des Animaux et des Végétaux, et sur leur motilité, par M. H. Dutrochet. Paris, 1824.

The result of these observations and real or supposed analogies is, if plainly expressed, that a large body, as of a man, or of a tree, is, in fact, nothing else than a vast bag of animalcules tied together, and obliged to subsist within one skin or bark.* To use the terms in which this conclusion has been expressed by one writer—"The simple organic con-

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* Dr. Edwards conjectures that the principle of aggregation between these organized molecules is analogous to crystallization. His theory is expressed in the following passages:—

"On voit donc que la structure intime des divers tissus qui composent les animaux présente partout des caractères analogues, et que la forme globulaire est toujours celle qu' affectent les élémens organiques de ces parties. L'animal le plus compliqué, comme celui qui est le plus simple, n'est formé que d'un nombre plus ou moins grand de ces corpuscules, dont la nature chimique peut différer, mais dont la forme et, probablement, le volume ne varie que peu." "C'est de la manière dont ces globules se réunissent que dépendent les caractères physiques des differentes parties qu'ils constituent, et de leur agglomération, dans un sens plutôt que dans un autre, que dépend la forme des divers organes, et de l'être qui résulte de leur assemblage."

"Le résultat des recherches que je viens d'exposer conduit naturellement à examiner si la forme globulaire qu' affectent les élémens organiques n'est imprimée qu'aux particules assimilées aux êtres vivans et dépend par conséquent de l'influence de la vie, ou bien si certaines substances la présentent toutes les

stituent parts of plants and animals dissociated, are capable, in certain circumstances, of independant life; in this state they are susceptible of two different modes of existence, one in which they are incapable of motion, the other in which they are capable of great locomotive power. The same being may therefore be modified so as to exhibit the appearance of vegetable or animal life. The death of a particular being, or a solution of the organization of which it is complicated, does not destroy the susceptibility of life, in its organic constituent parts; a certain process of decomposition gives life to these parts when separated, after a cessation of life in the entire being of which they were primitively a portion. This process of decomposition consists in a separation and modification of the organic parts, or of the most elementary organs. A total decomposition or resolution of the vegetable or animal substance into its ultimate chemical principles, *viz.* carbon, oxygen, hydrogen, and azote, is the only thing that can utterly destroy all susceptibility of life in the constituent parts; for, as long as organization, however simple, remains undisturbed, there is a capacity for life; and the transformation which hourly takes place during the progress of nutrition in general and of digestion in particular, a transformation of vegetable into animal, and of animal into

fois qu'elles passent de l'état liquide à l'état solide, de même que les sels affectent, en crystallisant, telle ou telle forme determinée. Une experience tres rémarquable de MM. Prévost et Dumas, parait favorable à cette dernière opinion."—Edwards, ubi suprà, p. 390.

vegetable substance, together with the restoration of life to those substances which are used as food, and which when thus used are destitute of life, is not confined to the living apparatus of animals, but is capable of taking place out of them."[*] By another writer we are told, "that the human body, with all its organs, is built up of animalcules, and that it is a congeries of countless millions of organized beings, each capable of living in a separate state, and perhaps of exercising some of the functions of individual life, whilst incorporated with our system."[†]

Objections against this new view of the mode of existence of organized beings, were pointed out by an anonymous writer in a foreign journal, distinguished for advocating the cause of good sense and sound philosophy.[‡] It was not difficult to show that the ordinary phenomena of the decomposition of organic bodies are unfavourable to the opinion that its constituent parts are possessed of separate life. It is evident that all the experiments which have been thought to disprove equivocal generation, are equally conclusive against this hypothesis.

But an entirely new aspect to all the facts connected with this novel speculation, has resulted from the well-known experiments of Mr. Brown, in which it appeared that active molecules, or, rather, moving particles, are seen to arise from the mechanical decomposition of hard substances never endowed with life. Particles in powdered glass or flint were seen to be just as active and self-moving, or, rather, moving in a manner not easily explained, as the monades or moving atoms which resulted from the disintegration of animal and vegetable substance.

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[*] Westminster Review.

[†] See Remarks in the Medico-Chirurgical Review for April, 1828, p. 447.

[‡] American Journal of Science and Arts, conducted by Benjamin Silliman, M.D. &c. No. 1, of vol. 15.

The result of these observations of Mr. Brown's is to shew, not that particles of powdered glass are living atoms, but that the moving atoms which arose from the decomposition of animal and vegetable bodies, were probably not endowed with life, but were moved by some other influence.

The investigations pursued by the French physiologists into the texture of solid parts, have been repeated by Dr. Hodgkin and Mr. J. J. Lister, with the advantage of a much more powerful instrument, and the results of these last inquiries are very remarkable and important. Their observations accord with those of MM. Prévost and Dumas, as to the shape of the particles of the blood, which appear to have a circular form in the mammalia, and an elliptical one in the other three classes of animals, but they differ essentially from the opinion of those gentlemen as to the structure of the globules. According to Dr. Hodgkin and Mr. Lister, the globular structure which Dr. Edwards thought he distinctly traced in the substance of muscle, nerves, and brain, has no real existence. The two former consist essentially of fibres, and the material of the latter breaks into very small particles, which are of irregular size and shape, more dependant on the disintegration than on the organization of the substance.*

On the irreconcilable discrepancy between these microscopical observers and Dr. Edwards, I shall scarcely offer any comment. To both parties are well known to belong great talent and accuracy of research, but Dr. Hodgkin and Mr. Lister had the most powerful instrument. It still remains, then, very doubtful whether the ultimate structure of organized substance consists of globules, and the remarkable movements of animal and vegetable particles or molecules, after a certain degree of disintegration, is still a fact unaccounted for; but it is no longer to be attributed to the vitality of atoms, since it takes place in inanimate substances.

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* Dr. Hodgkin and Mr. J. J. Lister's Microscopical Observations on the Blood and Animal Tissues.—*Phil. Mag.* 1827.

FINIS.

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